

The Blast Furnace and Steel Plant

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The Blast Furnace *and* Steel Plant

Vol. XIV

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No. 11

AMBITION

ARE you too big a spoke for the wheel or too round a peg for the hole you have to fit in your organization? If you are, reshape yourself accordingly. Then your true measure will become self-evident and your ambition will be considered worthy and commendable.

The merely ambitious man or woman is never sufficiently appreciated—in his own opinion. And he always carries his grievance with him, showing that he does not quite fit in or belong. In the words of the immortal Lincoln, he should “get out or get in line.”

We do not use the word Ambition nowadays in exactly the Shakespearean sense, usually applying it to aspirations and aims directed beyond the extreme outposts of duty. But there is invariably a long bridge that must be crossed step by step, between the beginning and realization of aims and aspirations, and these two by themselves, representing Ambition, are insufficient.

Ambition alone, unsupported by singleness of purpose, willingness to work, patience, and a broad sense of justice, is bad to have around an office or a business. By itself it breeds all sorts of dissensions and gets very much in the way of team spirit and efficiency.

But it is a great advantage to an organization to have a-many active, reliable, aspiring people who are ambitious for a chance to work themselves up by their own merit to more important trusts.

Animated by that sort of ambition, they will advance naturally, as a matter of course, once they have found their right work, and soon become not only satisfactory to themselves, but valued members of an official family.

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Waste-Heat Boilers in Steel Mills*

The Economic Value of Waste Heat Recovery in Open-hearth Steel Furnaces is Dealt With—Water-tube and Fire-tube Boilers Compared—Typical Installations Discussed

By F. H. WILCOX† and J. C. HAYES, Jr.‡

THE marked success of some recent installations of fire-tube waste-heat boilers has revived the interest of many engineers and plant operators in the recovery of heat from comparatively low-temperature waste gases. Experience continues to indicate that many of the accepted rules of boiler design for direct firing do not apply in waste-heat practice.

Differences in Principle in Direct-Fired and Waste-Heat Boilers.

It is generally conceded that close to 70 per cent of the total heat absorbed in a direct-fired standard water-tube boiler occurs in the first rows of tubes exposed to the radiant heat of the furnace, which is ordinarily not more than 15 per cent of the total water-heating surface. It is for this reason that one feature common to all successful types of direct-fired boilers is that of rapid and positive water circulation in the tubes thus exposed.

In the waste-heat boiler utilizing waste heat at 1200 deg. F., the radiant heat available is less than one-tenth of that available in a direct-fired boiler where furnace temperatures of 2700 deg. or over prevail. Therefore rapid water circulation is not a prime requisite in the waste-heat boiler, but it is highly important that the waste-heat boiler accomplish the maximum heat recovery by conduction and convection. Consequently it must be arranged to produce the most intimate possible contact of gases and water-heating surface.

It is essential that the waste gases pass as close to the heating surface as possible, and there must be a positive scrubbing or tumbling action which can be brought about only by close tube spacing in the case of a water-tube boiler, or the use of small-diameter tubes in a fire-tube boiler. In either case it is necessary to pass the gas at a velocity higher than is possible in most cases by natural draft alone. The velocities employed are high enough to break up the definite stream lines along which the gas tends to flow, and to prevent the formation of an insulating film of cool gas close to the heating surface which would otherwise allow a hot center or core of gas to pass on without giving up its quota of heat. In Fig. 1 the variation of the character of the fire-tube gas flow at different velocities is indicated diagrammatically.

Heat Transfer and Draft Loss.

The two most important requisites in proportioning boilers for a given amount and temperature of waste gases are a high rate of heat transfer and a low draft loss. Both depend on mass velocity, which for purposes of comparison is generally taken as the weight of gas in pounds per hour divided by the area

of gas passage in square feet; but the draft loss varies as the square of the velocity, so that the boiler arrangement designed for attaining a high heat-transfer rate must be compromised to keep the friction loss within economical limits.

It so happens that whereas the water-tube boiler at a given mass velocity and tube diameter has a higher heat-transfer rate than the fire-tube type, nevertheless the friction loss in the fire-tube boiler is much less.

Because of its low friction loss the mass velocity may be raised in the fire-tube type of waste-heat boiler, and consequently the rate of heat transfer may be so increased as to exceed that obtained in the water-tube type, while keeping the friction loss the same.

Fire-Tube and Water-Tube Boilers Compared.

Figures have repeatedly been published comparing fire-tube and water-tube boilers on this basis, assuming always the heating surface on the gas side in both cases to be perfectly clean. The fire-tube boiler shows up to much better advantage in actual practice on account of the ease with which the heating surface may be maintained practically free of dust deposits and the difficulty of maintaining the water-tube boiler in the same condition.

In Fig. 1 the paths of gases in fire-tube and water-tube boilers are contrasted. In direct-fired practice there is a definite advantage in a design that passes the products of combustion across the tubes substantially at right angles to the center line of the tubes as in the vertically baffled, horizontal, straight-tube types, over the design that passes the gases parallel or nearly parallel thereto. This advantage in direct-fired practice is largely discounted in waste-heat practice for the reason that much greater quantities of gas are passed per unit of heat transferred, and a greater draft loss occurs for the same weight of gas passed per square foot of gas-passage area, imposing a correspondingly greater load on the exhaust fan. The net evaporation is substantially the same for either type of water-tube waste-heat boiler. While a number of water-tube boiler types have parallel flow over a large part of the heating surface, the flow at the entrance, cross-over, and exit passages is substantially at right angles to the tube center lines. This latter type is generally baffled for two passes and has the lowest relative draft loss of any of the water-tube types.

It is evident that no practical combination of tube spacing and baffling of water tubes can possibly bring about as close a contact of the gases with the heating surfaces as is possible in a fire-tube boiler for the same draft loss. Obviously, where 2-in. tubes are used, none of the waste gas can be further than 1 in. from the heating surface in passing through the boiler, and consequently the heat transferred by conduction alone has the shortest possible path.

Gas should pass through the boiler with the least possible number of changes in direction of flow, and

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‡Freyn Engineering Company.

with the least possible loss due to irregular channels of flow. The ideal gas path, then, is that offered by a continuous single circular passage, such as the inside of a tube, and the smaller the diameter can be made, the closer will the gases adhere to the heating surface and the better will the heat transfer be. This design does not allow any short-circuiting of gases through baffles, or any by-passing of heating surface due to dead pockets in the path of travel. There is no path of least resistance; all tubes are of the same diameter, and there is no baffling.

Necessity for Frequent Tube Cleaning.

In order to obtain the maximum economy with any type of boiler in waste-heat practice, it is absolutely essential that the heating surface be kept clean in the fullest sense of the word. This is one of the most troublesome operating problems, and while the frequent use of permanent and hand soot blowers is fairly efficient on the outside of tubes, the best results are obtained where a steam or air jet is introduced at the end of a long tube where the steam or air is closely confined in the tube, and the entire length is thoroughly scoured in a few seconds. This is really one most important feature of a single-pass horizontal fire-tube boiler in that it insures the same performance day after day as obtained in test under the best supervision.

Fig. 1 also shows the method adopted for dusting tubes, which is accomplished by opening only two small wickets, one for observing the operations and

one for the introduction of the steam lance. The entire tube heating surface is cleaned in this way as frequently as desired. In the case of a boiler taking waste gas from an open-hearth furnace, once in 12 hours is frequent enough to prevent a rise of over 10 degrees in the final gas temperature.

Types of Boilers.

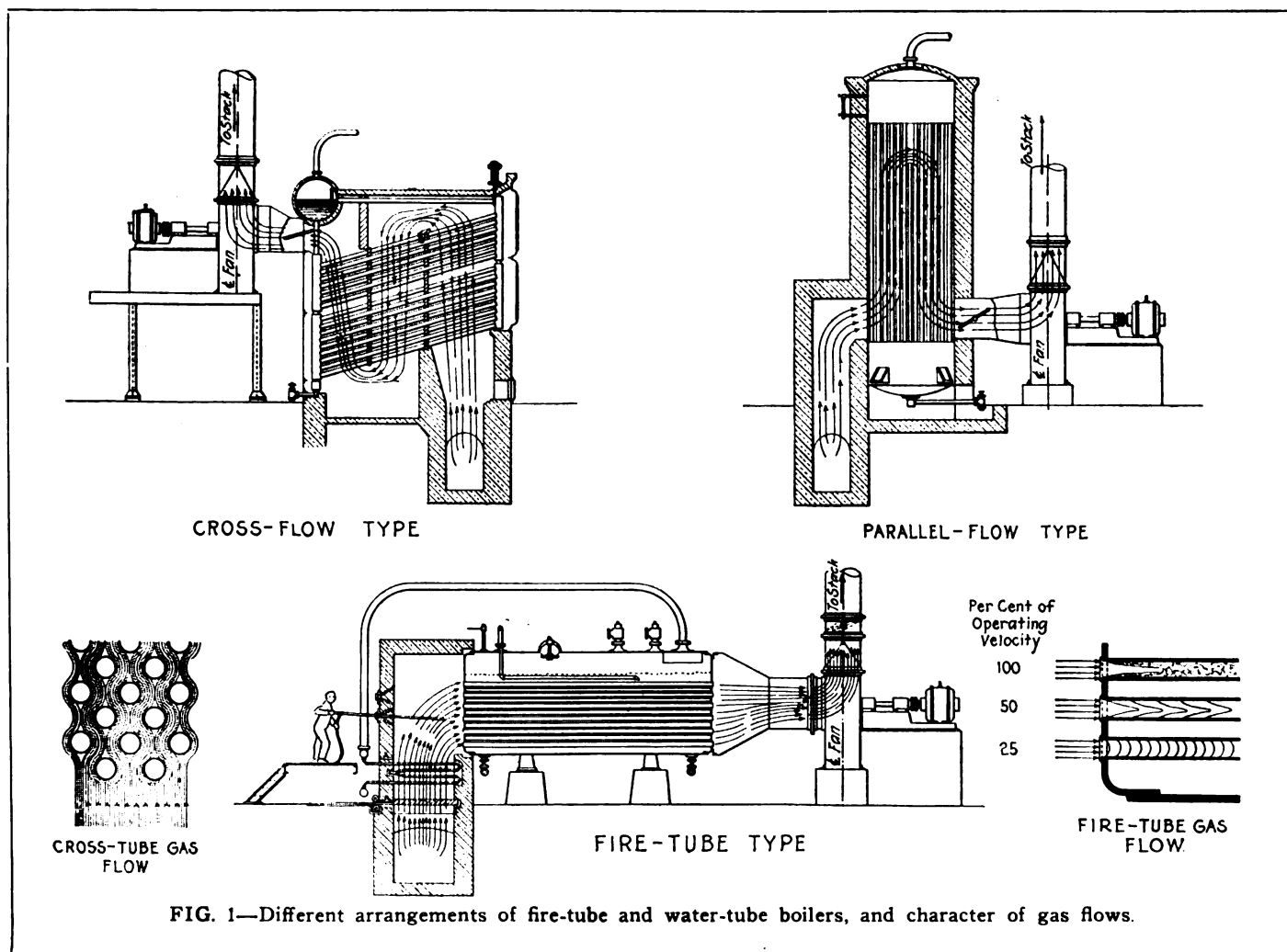
Some rather discouraging results have been obtained in attempts to use cross-tube boilers for the recovery of heat from furnaces wasting gas at 1200 deg. F., although these same boilers are giving excellent results in recovering heat from forge furnaces where gases are wasted at temperatures exceeding 1800 deg. F. This is simply further proof of the effect of heat transmission by radiation.

The amount of heat transferred by radiation varies about as the fourth power of the temperature difference between the tubes and the radiating surfaces.

Contrasting a boiler set over a forge heating furnace where the initial temperature of waste gases averages 2000 deg. F., and a waste-heat boiler set in the path of waste gases from an open-hearth furnace where the initial temperature is 1200 deg. F. the absorption by radiation factor would be as follows:

$$\frac{T_c^4}{T_w^4} = \frac{(2000 + 460)^4}{2460} : \frac{(1200 + 460)^4}{1660} \text{ or } 4.9:1$$

The comparison of heat absorption by radiation in the two cases is thus 4.9 to 1 in favor of the higher



temperature range, and correspondingly less heat absorption is necessary by conduction and convection to make a credible showing in the amount of heat recovered. As stated before, this ratio would be 10 to 1 in case the same boiler were used over a furnace having 2700 degree flame temperature.

The water-tube boiler has an advantage over the fire-tube boiler in being more accessible for the removal of scale from the heating surfaces, so that the proper treatment of boiler feedwater should be assured in any contemplated installation of fire-tube boilers. Much prejudice against the use of a fire-tube boiler is based on the failure of its type to compare favorably with the water-tube boilers in meeting the demands of high-pressure stationary work. Many of the factors contributing to this feeling do not apply in waste-heat practice, and others have been eliminated or greatly minimized in modern fire-tube practice.

The waste-heat boiler does not have the high radiant heat to absorb, and it is therefore not necessary to resort to the customary means of passing the gases across the lower half of the shell as in the horizontal-return tubular setting, nor to install fireboxes, water legs, or other extensive stayed flat surfaces.

Advances have been made in the science of treating water for boiler-feed purposes, and a satisfactory treatment can be assured for practically any kind of water.

Experience has shown that tube leakage in a waste-heat boiler of this type is not a serious factor. The flow of gases is seldom over a very wide range in temperature. There is no occasion to open large firing doors, or otherwise let cold air strike the tube sheet, and tubes may be electrically welded to the heads if desired. In practice it has not been necessary to resort to electric welding in the horizontal settings, and some of these boilers have been in operation over three years.

Any loose mud or scale formations fall to the bottom of the drums and are kept away from the heated surfaces.

A much higher content of solids in solution in the boiler water is permissible on account of the comparatively low and steady rate of evaporation, the greater liberating surface for steam and water separation, and the large amount of contained water per unit evaporated. No brick setting is required to enclose the pressure parts, so there is no cold-air infiltration and very little heat lost by radiation. A fire-tube boiler may be installed in much less space than is necessary for a water-tube boiler of the same heating surface, and less heating surface for the same output is necessary in the fire-tube type. Installation cost is thus generally less for the fire-tube boiler.

Induced Draft in Waste-Heat Boilers.

Many existing installations of waste-heat boilers are heavily penalized in net return on account of the excessive use of power necessary to maintain furnace draft and draw the gases through the boilers.

The energy used in the fan drive for drawing the gases through the fire-tube boiler should not exceed 5 per cent of the boiler output where it is necessary to provide the equivalent of natural draft for furnace operation, and in such cases as puddle furnaces, forge heating furnaces, cement kilns, etc., where regenerators are not used the power for driving fans should not exceed 3 per cent of the boiler output.

Where regenerators are used, all water cooling of reversing dampers should be dispensed with if possible. In two recent installations, dry dampers set at an angle of 15 deg. from the vertical have been adopted and have proved entirely satisfactory. The straight-away gas passages offer the least possible obstruction of gas flow, and the absence of water cooling allows the waste gases to reach the superheater at the highest possible temperature.

As early as 1910, when the first experiments with water-tube boilers and low-temperature gases were conducted, it developed that much closer tube spacing and more restriction of gas flow by closer baffling were necessary in waste-heat work than in standard boiler practice. This naturally led to higher draft losses and correspondingly higher power consumption of induced-draft fans, even with perfectly clean heating surfaces. The difficulty of properly removing dust, baffle leakage, and air infiltration through brick settings were serious drawbacks in the first efforts to utilize water-tube boilers in this field, but have been to some extent corrected in later installations by the closer grouping of permanent soot blowers, supplemented by hand lances, the use of monolithic baffling, and enclosing the entire brick setting in steel jackets.

Test data obtained on one of two fire-tube units installed at the plant of the National Malleable & Steel Castings Company at Melrose Park, Ill., in connection with 25-ton open-hearth furnaces, are given in Table 1.

TABLE 1—TEST OF WASTE-HEAT BOILER*

Test	No. 1	No. 2	No. 3
Duration of test, hr.	7	8.25	8.75
Steam pressure, lb. gage	140.9	140.0	133.8
Temperatures, deg. F.:			
Gas before superheater.....	1348	1338	1331
Gas before fan.....	485	490	478
Steam after superheater.....	495	473	484
Feedwater	175	187	184
Drafts, inch of water:			
Before superheater	0.63	0.64	0.64
Before boiler (after superheater) ..	0.91	0.91	0.91
Before fan (after boiler)	3.20	3.19	3.20
Base of stack (after fan)	0.84	0.87	0.85
Evaporation:			
Total, lb.	53,485	65,169	75,095
Average, lb. per hr.	7,641	7,899	8,582
Average CO ₂ in waste gases (per cent by vol.)	9.06	8.71	8.55
Average oil consumed, gal. per hr....	152.7	155.2	160.5
Fan data:			
Speed, rpm.	644	651	645
Calculations and results:			
Boiler horsepower developed			
Total	258.0	261.8	286.5
Superheater	16.7	14.6	17.6
Boiler	241.3	247.2	268.9
Temperature of saturated steam, deg. F.	361	361	357.5
Superheat, deg. F.....	134	112	126.5
Weight of waste gases, lb. per hr.....	38,500	39,800	43,200
Input to fan motor, brake hp.....	18.1	18.9	19.5
Rating of boiler, per cent	102.5	105.0	114.5

*National Malleable & Steel Castings Company, Melrose Park Works, Melrose Park, Ill., June 17, 1925.

In this instance the heat contained in the steam delivered at the outlet of the superheater represents 39.2 per cent of the heat value of the fuel used in the furnace, and the fan used 2.8 per cent of the boiler output, leaving 38 per cent of the furnace fuel recovered in the form of steam. The three tests tabulated are simply three divisions of a continuous 24-hour test divided into the three periods for the pur-

pose of comparing the boiler performance over the three open-hearth heats taken out in the 24 hours.

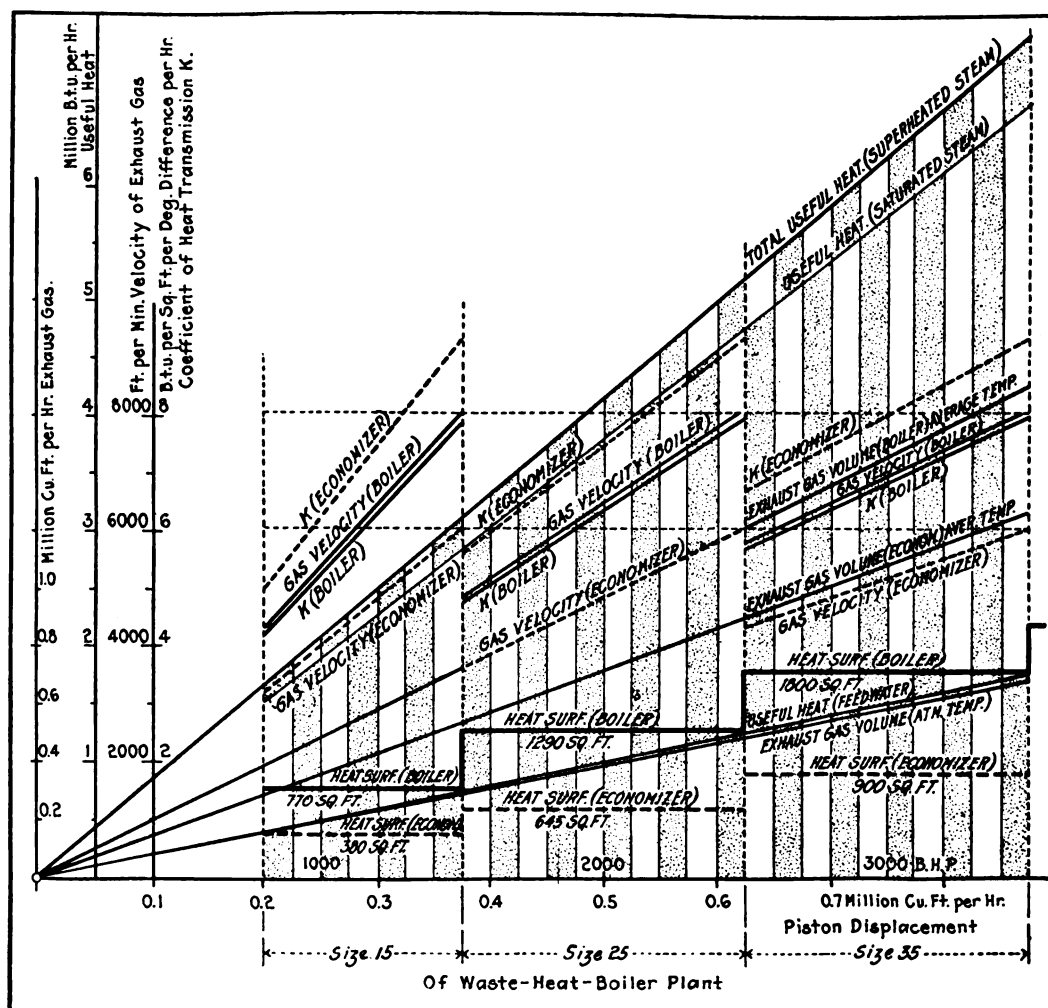
At Melrose Park there has been a marked improvement in open-hearth-furnace performance due to the better draft available since installing the waste-heat boiler, the furnace output having increased substantially 20 per cent over the former practice due to improved draft conditions.

The authors' experience has been that the induced draft incident to the use of a waste-heat boiler is not only an advantage in regular furnace operation by reason of having more intensity and being subject to

the United Alloy Steel Corporation, of Canton, Ohio, have 2-in. tubes, 18 ft. long. The Tennessee Coal, Iron & Railroad Company at its Fairfield plant has installed four boilers of this type, designed for two horizontal passes, of which only one pass of each boiler is installed at present. The second pass is designed to be used as an economizer element. Each boiler as installed has 5600 sq. ft. of water-heating surface in 2½-in. tubes, and is built for a working pressure of 250 lbs. As now operated, final gas temperatures are about 600 deg. F., with mass velocities of close to 11,000 lb. per hr. per sq. ft. of gas-passage area. The

FIG. 2—Performance of fire-tube boilers of three different sizes utilizing exhaust gases from blast-furnace-gas-driven engines.

Production of steam (170 lb. per sq. in., 573 deg. fahr.), 1.65 lb. per b.hp.-hr.
 Temperature of feedwater, 68 deg. fahr.
 Temperature of exhaust gases entering superheater, 1020 deg. fahr.
 Temperature of exhaust gases entering boiler, 940 deg. fahr.
 Temperature of exhaust gases entering economizer, 509 deg. fahr.
 Temperature of exhaust gases leaving economizer, 360 deg. fahr.
 Engine load, 65 lb. per sq. in. Mechanical efficiency, 84 per cent, corresponding to 250 cu. ft. per b.hp.-hr. piston-displacement suction.



better control than natural draft, but the life of regenerators is much longer than when depending on natural draft, especially where producer gas or other fuel is used that tends to deposit dust on the checker brick and to limit the length of time a regenerator may be used.

The first fire-tube boilers for waste-heat recovery were installed in the plant of the Illinois Steel Company at South Chicago, passing the gases through 3-in. tubes in two vertical passes for a total travel of 28 ft. Boilers of this same type were later installed with an economizer element as a third pass, in which the steam required to drive the induced-draft fan was about 10 per cent of the boiler output.

The first horizontal boilers were installed at the plant of the Bettendorf Company at Bettendorf, Iowa, and have 2½-in. tubes, 20 ft. long. The boiler reported on above has 2-in. tubes, 18 ft. long. Three boilers at

addition of the economizer element will reduce this to as low as 350 deg., depending upon feedwater temperature and surface installed.

Auxiliary Furnaces.

In many cases there is a demand for an auxiliary furnace so as to utilize the boiler for direct firing by oil or other fuel in the event of the boiler's being needed while the furnace is out of service. In designing these furnaces the superheater must be protected against the high furnace temperature of direct firing, but the boiler is otherwise operated in the same manner as a waste-heat unit. Gas velocities through the tubes are of course much lower for the same output, and the increased ratio of heating surface to the weight of gas passing gives an excellent heat absorption at rates up to 4500 Btu. per hr. per sq. ft. of heating surface. No attempts have been made to operate continu-

ously above this rate as it is feared that fire cracks would appear in the tube ends under the harsh action of excessively high temperatures in the front heads, although continuous operation at this rate has had no ill effect.

The auxiliary furnace must be designed to insure complete combustion of oil or gas before the products come in contact with the heating surface, and should have not less than 0.2 cu. ft. of furnace volume per square foot of water-heating surface in the boiler, and a flame travel of 20 ft. or more if possible.

Heat Recovery in Steel Furnaces.

To show the effect of the recovery of waste heat from open-hearth furnaces on the cost of finished steel, the following example is taken.

In a modern steel plant consisting of 80 coke ovens, two 500-ton blast furnaces, and 12 open-hearth furnaces and rolling mills for producing track material, structural shapes, plates, wire, and rods, for every ton of finished steel there will be required 0.73 ton of coke, 0.73 ton of iron, and 1.27 tons of ingots.

The coke ovens and blast furnaces will furnish enough fuel for their own operations, including steam, water, and power requirements. Excess coke-oven gas and blast-furnace gas is assumed to replace coal of 12,000 Btu. per lb., costing \$4 per ton, including the cost of unloading, firing, and ash disposal, and utilized at 70 per cent boiler efficiency.

Source:	Btu. available in surplus fuel per ton of finished steel	Credit to cost
Coke-oven gas	2,390,000	\$0.40
Tar	1,370,000	0.228
Coke breeze	1,000,000	0.168
Blast-furnace gas	4,000,000	0.66
Open-hearth waste heat ...	3,620,000	0.445

No modern steel plant would tolerate the waste of excess coke-oven gas, tar, coke breeze, or blast-furnace gas, although plants are now burning coal or buying power while making no attempt to reclaim the tremendous heat losses incident to high stack temperatures in open-hearth and other furnaces.

Waste Heat in Cement Kilns.

Cement kilns producing sufficient clinker for 1000 barrels of cement in 24 hours, yield about 83,000 lb. of waste gas per hour at a temperature close to 1100 deg. F. This is equivalent to 350 net boiler hp. per kiln. The authors do not know of any waste-heat installation of fire-tube boilers in this class of service, but it is thought that the use of a properly designed fire-tube unit would be especially desirable in this service on account of the well-known difficulty of keeping the heating surface of water tubes reasonably free from dust. Moreover, the volumes and temperatures of waste gases from these kilns are quite constant, and in a properly designed boiler the maximum heat transfer rates could be utilized at all times and the combinations of boilers, fans, and superheaters could be arranged to operate at or near the maximum on the combined efficiency-load curve.

Utilization of Internal-Combustion-Engine Exhaust Heat.

Interest has also recently been revived in the problem of recovering heat from the exhaust gases of internal-combustion engines. The European countries are considerably ahead of us in this field, but through

our European consultants we have kept in touch with developments.

Fig. 2 shows the performance of fire-tube boilers of three different sizes, utilizing various volumes of exhaust gases from engines using blast-furnace gas. These curves are developed from a large amount of actual test data on the three sizes shown, and clearly indicate that the coefficient of heat transmission increases directly with the increase in gas velocity in a given size of boiler tube. It is also of interest to note gas velocities as high as 8000 ft. per min. in utilizing the engine exhaust gases, whereas in using waste furnace gases the economic limit is about 4800 ft. per min. The possibility of such operation favors the application of waste-heat boilers to engine exhaust gas. High velocities may be reached by adding only slightly to the back pressure on the engines, which is not a serious consideration, while the power required in a suitable exhaustor for such high velocities in ordinary waste-heat practice would be prohibitive.

In engines of this type there is an ordinary yield of 2 lb. of high-pressure superheated steam for each brake horsepower developed by the engine. In fact this figure, or one very close to it, is established so well for each engine that any increase in steam production is taken as an indication of correct gas-air mixtures in the cylinders and poor engine performance, rather than of any change in boiler efficiency. In each instance the boiler performance is thus a guide to the operators in keeping the engine up to its best efficiency.

A typical heat balance of gas engine is:

	Per cent
Useful work	33
Lost in exhaust gas	36
Lost in cooling water	29
Radiation and unaccounted for	2
	100

By utilizing the waste gases in a suitably designed boiler, and in addition using a portion of the hot cooling water for boiler-feed service, the total of 36 per cent lost heat is reduced to 11 per cent, and the percentage of useful work extracted from gas is increased from 33 to 40 per cent. This is undoubtedly the highest recovery of heat in any practical prime mover in industrial use.

Diesel oil engines are now being built in units up to 8000 hp., in which substantially 30 per cent of the heat value of the fuel is lost in the exhaust gases. There is little doubt but that the near future will see the installation of fire-tube boilers in connection with many of the larger internal-combustion engines.

Study Refractories for Open Hearths

A rather comprehensive bulletin, "Service Conditions of Refractories for Open-Hearth Steel Furnaces," has just been published as one of the mining and metallurgical investigations conducted under the auspices of the Carnegie Institute of Technology, United States Bureau of Mines and Mining and Metallurgical Advisory boards. The work was conducted by B. M. Larsen, assistant metallurgist, and F. W. Schroeder, assistant chemist respectively, Bureau of Mines and E. N. Bauer and J. W. Campbell, Research Fellows, Carnegie Institute of Technology. The publication contains 119 pages of discussion, tables and illustrations, also a bibliography and complete index. Copies may be secured from Carnegie Institute of Technology, Pittsburgh, for \$1.50 each.

Diesel Engine Exhaust Gas Observations

Measurement of Temperature and Content of Carbon Dioxide and Hydrogen in Diesel Engine Exhaust Gases Makes It Possible to Determine Combustion Efficiency

By ING. M. U. BUCHTING and G. DINKELA

It is surprising that in the extensive literature on Diesel engines, the question of exhaust gas composition has received very little attention. Ordinarily in the description of Diesel engine tests the appearance and scent of the exhaust gases is given. The reasons for this neglect of the exhaust gas analysis is no doubt due to the fact that the designer does not like to work with chemical apparatus. In the last few years, though, the technical apparatus for gas analysis based on physical principles has been improved, so that its use has found a place in most branches of science.

To observe the combustion process in the cylinder of an internal combustion engine has previously only been done by means of the indicator diagram. The continuous control of an engine with an indicator by untrained men is troublesome and costly. The experience and the capability of the individual has up to date replaced the control instrument. It is now possible to control the combustion in the cylinder by means of the exhaust gases as is being done at present with most combustion processes. The combustion is adjusted by the composition and temperature of the exhaust gases, and only in this manner is it possible to observe the changes in combustion and by the proper evaluation of the exhaust gas analysis is it possible to achieve the highest efficiency.

With internal combustion engines the process of combustion is very much more complicated and many factors influence the composition in the cylinder. However, the analysis of the exhaust gas is an important means for both the designer and the operator to draw conclusions on the occurrences inside the cylinder. Internal combustion engines are divided into two groups: The high speed automotive engines and the low speed Diesel engines. The combustion in the cylinder of the high speed internal combustion engine is not complete. Its exhaust gases always contain more or less carbon monoxide and hydrogen, the recognition of which is the main purpose of the exhaust gas observation of internal combustion engines, since it is incomplete combustion which causes heavy losses. We have made tests on this and described a method to determine, while operating, the unconsumed gases in the exhaust of high speed internal combustion engines by means of the Siemens and Halske CO + H₂ Meter.*

With Diesel engines the combustion takes place more slowly. The air highly heated by compression is present in excess and the combustion takes more time. For this reason there are no unconsumed gases in the exhaust gases with correct ignition and combustion so that by means of measuring the carbon dioxide and the temperature of the exhaust gases the combustion can be observed and the operation of a Diesel engine can be controlled. The tests described here show plainly to what extent it is possible to recognize irregularities—which come up with a Diesel engine during operation—by means of analyzing the

exhaust and measuring the temperature and by determining the influence of load, revolutions per minute, temperature of fuel and cooling water on the exhaust gases.

The tests were made on a horizontal, two cylinder, four cycle, belt drive, Koerting solid injection engine with a rating of 200 hp. at 180 rpm. driving a pump. The carbon dioxide meter was a Siemens and Halske flue gas meter† which is based on the principle of measuring the difference in heat conductivity between air and carbon dioxide.

For measuring the temperature two Siemens and Halske copper-constantan thermocouples with one indicator were used. The tester of the carbon dioxide meter with its indicator was attached on a panel on which the indicator of the thermocouple was also mounted. The panel was fixed on the wall at an

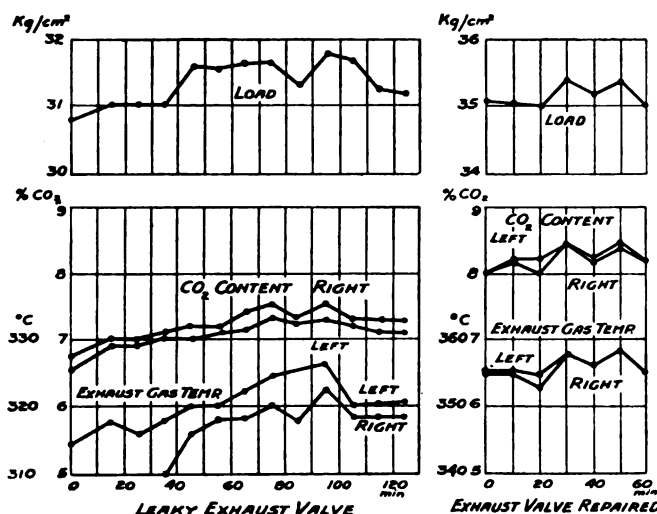


FIG. 1.

FIG. 2.

Results of exhaust gas tests.

easily visible point. Copper tubes (8 m/m in diameter), which could be shut off by means of a cock, were screwed into the two exhaust pipes of both cylinders. The gas lines led into a filter with glass wool and cotton. Under the filter there was a condensing pot. The gas lines led from the filter to the CO₂ tester. Close to the entrances of the gas lines the copper-constantan elements were built into the exhausts so as to extend in 15 cm. The thermocouples were protected against chemical attack from the exhaust gases by a very thin iron tube. The connections of the thermo-elements led to a switch by means of which the indicator could be connected to either of the two thermo-elements. By means of a two-way cock the exhaust gas lines could be connected to either of the cylinders. The time lag of the CO₂ meter was 1 to 2 min., the time lag of the thermocouples approximately 2 minutes.

Fig. 1 was obtained as follows: Every 10 minutes the temperature and the CO₂ content of the exhaust

gases of both cylinders and the pressure of the pump driven by the Diesel engine were read.

The cooling water was kept at a temperature of 50 to 51 deg. C. The governor kept the speed at 180 rpm. The engine worked with one-fifth ignition and four-fifths tar oil.

The course of the curves shows that the exhaust gases of both the cylinders do not have the same analysis. In addition the dependence of CO₂ content and temperature upon the load of the machine can be easily recognized. With a higher load both curves rise. CO₂ content and temperature are different for both cylinders. The cylinder at the left has lower CO₂ content in spite of higher exhaust gas temperature. This is surprising, since if the load of one cylinder were higher both values should rise. This, however, holds only with equal degree of compression. If a valve of one of the cylinders is not tight the compression drops. Then a smaller quantity of air is available for the combustion because part of the air escapes due to leaks. At the same time the temperature of the air in the cylinder drops. With the same quantity of fuel and perfect combustion the cylinder with low compression shows a higher CO₂ content in the exhaust gases because the amount of excess air is smaller, but it shows lower exhaust gas temperatures because the combustion temperature is lower.

Not only the load of the individual cylinders can be tested by means of gas analysis and measurement of temperature, but also deviations of the normal operation of the engine can be checked.

The valves were then repaired and Fig. 2 shows the same test under the same conditions after adjustment. The load of the engine was somewhat higher; for this reason the temperatures and the CO₂ contents were higher too. With both cylinders the value is nearly the same. This means an equal load on both cylinders and the same compression in both of them.

If the fuel feed does not work uniformly, that is, if one of the cylinders gets more fuel, it can easily be recognized on the exhaust. CO₂ content and exhaust temperature vary very much in this case. For instance, with one test the left cylinder gave 8.0 per cent CO₂ and 370 deg. C., the right one at the same time 5.5 per cent CO₂ and 290 deg. C.; a few minutes later it was reversed, the left cylinder had 6.5 per cent CO₂ and 300 deg. C. and the right one 8.0 per cent CO₂ and 340 deg. C. Ten minutes later, again both values had changed; at the left 6.2 per cent CO₂ and 295 deg. C. and at the right 8.1 per cent CO₂ and 375 deg. C. Since the temperatures, compared to the first test, varied in the same manner and higher CO₂ content corresponded with higher temperature of the exhaust gases, the compression was the same in both cylinders and the varying load was caused by the irregularity of the fuel feed. If the nozzles had been the cause of this irregularity, the values would have varied only in one cylinder. After the fuel feed had been adjusted, both cylinders work alike.

The composition of the fuel affects the combustion process and with this also the composition of the exhaust gases. A test was made with a Diesel engine using different fuels with equal load and equal rpm. With American crude oil of 10,650 Kcal/kg. and 77.1 per cent carbon the analysis of the exhaust showed 5.7 per cent CO₂ and 325 deg. C. With one-fifth crude oil and four-fifths tar oil of 9,850 Kcal/kg. with 78.8 per cent carbon and 7.4 per cent hydrogen and with

equal load there was 6.0 per cent CO₂ and 325 deg. C. and with greater load 6.2 per cent CO₂ and 330 deg. C. for crude oil and 6.7 per cent CO₂ and 330 deg. C. for operation with tar oil. Tar oil gives a higher CO₂ content of the exhaust gases because it contains more carbon and because the consumption of fuel is somewhat higher than with crude oil on account of the smaller heat value.

If the cooling water temperature of the cylinders rises, then also the CO₂ content of the exhaust gases and the exhaust gas temperature will rise. With equal load and equal rpm. at a cooling temperature of 40 degrees there were measured 6.2 per cent CO₂, 305 deg. C., with 50 degrees cooling water 6.4 per cent CO₂ and 315 deg. C. At higher temperature the weight of air which is aspirated is somewhat smaller since the volume of air always stays the same. That the temperature of the exhaust gases rises with rising cooling water temperature is obvious.

The tests described here were carried on under actual operating conditions. The metering apparatus required no attention and does not require an experienced operator. For engines having a greater number of cylinders this method of observation is especially suitable, since it is extraordinarily sensitive and indicates the smallest disturbance in the engine. The designer also no longer need judge the exhaust gas composition of his engines by scent and appearance, but he can examine the combustion in the cylinder. Both on the test stand and in operation in addition to the measurement of temperature, the analysis of the exhaust gases also should no longer be omitted.

*Bulletin 253. †Bulletin 250. Bacharach Industrial Instrument Company.

To Install New Billet Heating Furnace

The West Leechburg Steel Company of Leechburg, Pa., has recently placed an order with The Chapman-Stein Furnace Company, Mt. Vernon, Ohio, for a complete recuperative, billet heating furnace of the very latest design. It is to have a normal capacity of 15 net tons of billets per hour when heated from cold to rolling temperature. It will handle material 20 ft. long, ranging in sizes from 1¼ in. square to 3¾ in. square.

This furnace will be a side charge, side discharge type with a solid hearth, and will have a suspended roof. There will be no water cooled parts used, as it is designed for the best possible fuel economy. Hence, everything possible will be done to reduce heat losses.

Their selection of this furnace followed a very thorough investigation of numerous furnaces in operation. The purchasers satisfied themselves that this type of furnace shows the lowest fuel economy, stands up longest under normal steel plant operation, operates with a low oxidation loss, and as a result shows the lowest overall heating cost.

The recuperator is to be built with time-tested Chapman-Stein recuperator tile. By the process of manufacture now used, these tiles are kept to within 1/64 in. of the dimension called for. Such accuracy in the making of special refractories of this type has never before been reached. It results in a refractory tile recuperator which is capable of withstanding most any temperature that may ever be desired and one which stands up for a long period without showing any tendency to leak or requiring any repairs. The recuperator and furnace will operate without a fan.

Care and Maintenance of Wire Rope

Life of Wire Rope Depends Greatly on How the Rope Is Installed
and the Care Given It After Installation—This Article
Will Be Beneficial to All Who Handle Wire Rope

By WALTER VOIGTLANDER, M.E.*

EVERY engineer will subscribe to any reasonable policy or method that will reduce operating expenses at no sacrifice to efficiency. Naturally the interest in such a method will be greatly increased when it is shown that the departure from standard practices will not only decrease expenses but simultaneously increase efficiency.

It would perhaps be improper to say that one part of a machine was more important than another part, since all parts are so interdependent that to give effi-

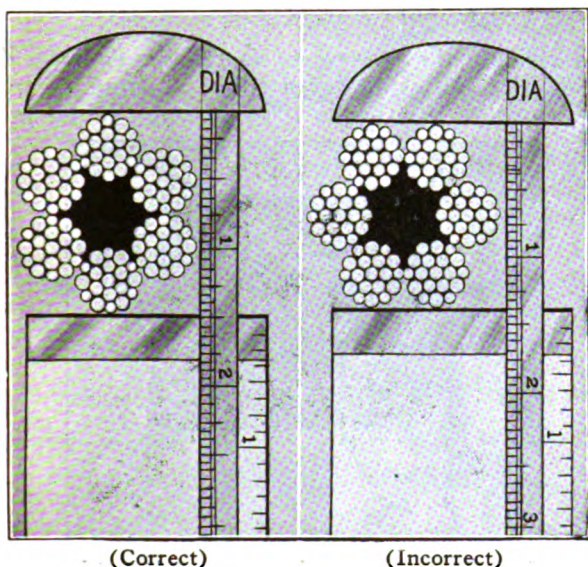


PLATE No. 1—Illustrating by contrast the correct and incorrect method for measuring wire rope.

cient service every machine must act as a unit. Wire rope is a major operating element in hoists, and it is the two-fold purpose of this article to show how a possible change or correction in wire rope usage may both decrease operating expense and increase general efficiency; and to present the best known methods for wire rope maintenance.

For nearly 100 years wire rope has remained pretty much the same in the matter of general fabrication, with the result that to the great majority of superintendents wire rope was just wire rope, with little or no semblance of individuality or identifying characteristics. Such an impression was more or less justified up to three or four years ago when a practical means was found whereby the wires and strands that enter into the construction of wire rope could be preformed or preshaped. This discovery permitted the development of a revolutionary change in wire rope manufacture.

Instead of merely twisting a number of wires into a strand, then twisting several strands into a complete rope (which twisting would naturally result in great internal strain thus reducing the resiliency and over-

all efficiency of the completed rope, the preformed wires and strands were laid in place without force or twisting. The obvious result was a rope more nearly approximating mechanical perfection. The applied loads are more evenly distributed throughout the component wires and strands thus reducing unbalanced wire stresses. This yields an actual higher safety factor.

The fact that preformed rope will not unravel when untied at the ends proves the absence of a torsional stress that exists in ordinary rope and so again internal torsional stresses are known to have been reduced to practically nil. These two features yield a greater useful allowable stress in the wires for actual operating service.

When the separate wires in a rope break they invariably stick out from the rope, frequently bend back and break off, leaving a gap in the strands. This causes less bearing surface on both the remaining



PLATE No. 2—How to and how not to handle wire rope. See text for detailed explanation.

wires and the sheave. With the wires and strands preformed, broken wires lie flat, thus protecting both the remaining wires and the sheaves.

How to Measure Wire Rope.

There is only one way to correctly measure wire rope and that is shown in contrast to the incorrect method, by the accompanying illustration (Plate No.

*Rope Engineer, American Cable Company.

1). It is highly important that the proper size of rope be employed since an undersized rope will not give the degree of service that should reasonably be expected, while an oversized rope represents needless investment and will not properly operate over sheaves grooved for smaller ropes. More important, however, is to have the rope and the sheave properly fitted. Wire rope should not be allowed to travel over a sheave wherein the groove is too small for its diameter. A pinching sheave will do more damage to a wire rope in one hour than a properly grooved sheave in an entire week or more. Sheaves grooved 1/16 of an inch larger than the diameter of the rope will lengthen the life of the rope several times as compared with rope life on pinching sheaves. Since sheaves are cheaper than good wire rope, there is small economy in continuing the operation of improperly grooved sheaves or drums. Also the tread diameter of the sheave or drum greatly effects rope life. Large diameter sheaves should be used wherever possible.

Uncoiling or Unreeling Wire Rope.

Wire rope is ordinarily shipped and received in coils or on reels. When uncoiling or unreeling wire rope it is very essential that no kinks are allowed to form. Once a kink is made, no amount of twisting or strain can take it out and the rope is unsafe for work. Never uncoil a wire rope as might be done with a rubber hose or manila hemp rope. Lift the coil to its edge and unroll the coil, allowing the rope to lie flat until used. Contrasting methods are shown in the accompanying reproduction (Plate No. 2).

When wire rope is received on a reel it must never be taken off or unreeled, as shown in the "wrong way" illustration, for such a method will invariably develop kinks and spoil the rope. If a jackbracket for the coil is unavailable (as shown in Plate No. 2-A) turn the reel on edge and roll along the ground.

Lubrication.

The cores of practically all good brands of wire rope, both the preformed and non-preformed types, are thoroughly impregnated with a commercial chemically-neutral rope oil. While the coil retains a liberal supply of this lubricant which gradually oozes out as the rope is used, still, frequent application of a good lubricant during service is necessary to prevent the core from becoming dry. A dry core will both wear and crush more quickly than one that is thoroughly lubricated. It will also absorb moisture readily with the result that the core will deteriorate rapidly and the inner wires corrode.

The smaller the sheaves or the heavier the tension on the rope, the more often should the rope be lubricated so as to prevent the too rapid wearing of the core in the first case and the excessive crushing in the latter case.

A good lubricant will retard corrosion of the wires, slacken deterioration of the core, reduce internal friction and decrease external wear. The lubricant should be thin enough to penetrate the strands and the core but not so thin as to run off the rope. Ordinarily, a thick, semi-plastic compound applied hot and in a thinned condition is best wherever possible. It will penetrate while hot, then cool to a plastic filler, thereby preventing the entrance of water. In this way the inner wires and cores are both preserved and lubricated.

To properly lubricate with a heated lubricant, it is necessary to have the rope run slowly through the

tank of heated oil. In this way proper penetration is effected. Where this is not possible, an application of a thinner, unheated lubricant will give better and more practical results.

It is well to lubricate a rope just after installation and before running in service, particularly if the rope has been kept in storage for some time.

How to Splice Wire Rope.

In order to prevent appreciable loss of strength at the splice, it is customary to make the length of splice not less than that given below for ropes of different sizes:

Diameter of Rope	Length of Splice
Inch	Feet
$\frac{1}{2}$	15
$\frac{5}{8}$	20
$\frac{3}{4}$	24
$\frac{7}{8}$	28
1	32
$1\frac{1}{8}$	36
$1\frac{1}{4}$	40
$1\frac{1}{2}$	45

In splicing the two ropes, fasten the ends so that they overlap, allowing for a splice of from 15 to 45 feet as indicated by the above table. For the purposes

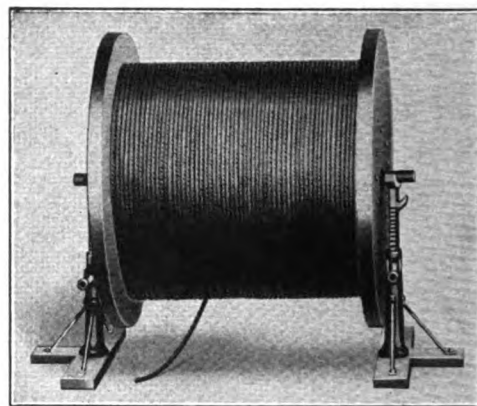


PLATE No. 2-A—Jackbrackets provide the best possible means for unreeling wire rope. With this equipment there is little possibility for kinking.

of explanation, we will assume a 30-foot splice. First wrap or tie the ropes securely with iron wire 30 feet from each end, then unlay all strands 15 feet as shown in Fig. 2, cutting away the hemp core to permit bringing the two unstranded ends together in order that the several strands will interlock as in Plate No. 3, Fig. 3.

Take strand a and unlay it until the wire binding is reached, and in the open groove place strand A. Lay A in tightly as shown in Fig. 4, making the twist agree exactly with the twist of the open groove. Proceed in this way until all except two feet of A are laid in and then cut off a and A, leaving ends about two feet long. Now unlay strand B in the opposite end and in its place put strand b, stopping the end of the rope in the corresponding position to A, Fig. 4.

Subsequently c will be replaced by C, but this should be stopped six feet short of the junction of A and a, as shown in Fig. 5. Similarly, D should be replaced by d and the end stopped six feet short of Bb. Proceed similarly with Ee and Ff, stopping the ends six feet short of Cc and Dd respectively.

The rope will now present the appearance shown in Fig. 5 and the only remaining step is to tuck in the ends in such a way that the diameter of the rope will

not be increased where the ends are tucked in. This is done by removing the hemp center and putting the ends of the strands in the place previously occupied by the core. To do this, it is first necessary to open up or untwist the strands at Aa so that the hemp center can be seized with a pair of pliers and pulled

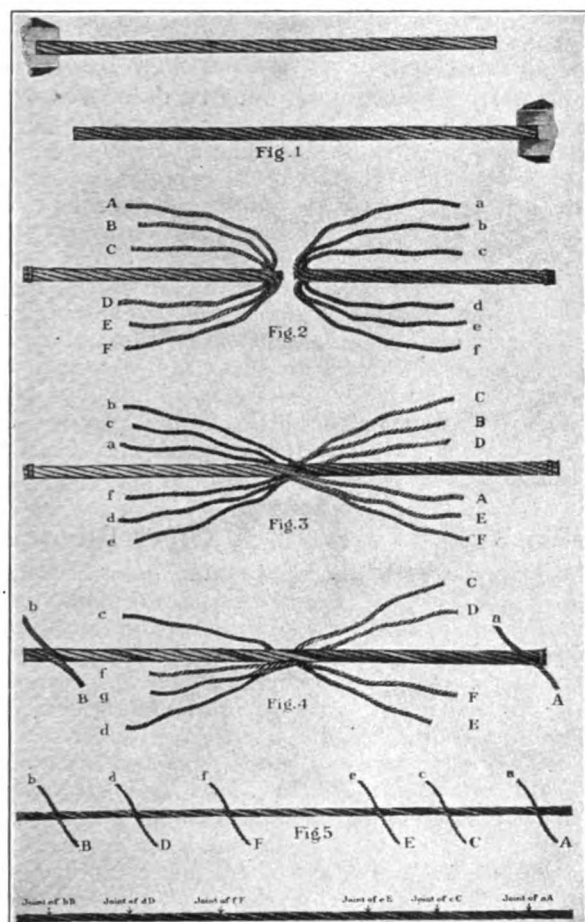


PLATE No. 3—Illustrating the method for splicing wire rope. For details see text of article.

out. Then a marline spike is inserted under the two strands nearest the end of the rope, and after starting the loose end into the space left vacant by the hemp, rotate this marline spike so as to force the strand into place. Repeat this operation at Bb, Cc, Dd, Ee, and Ff, then hammer the spliced rope lightly with a wooden or copper mallet to give the rope a uniform diameter.

Seizing.

The end of an ordinary wire rope should have at least three seizings to prevent unlaying, which, if it occurs, would render the rope useless. The seizings may be replaced by fittings if they prevent unlaying. Annealed iron wire should be wound tightly in a close helix around the rope.

1—Wind the seizing wire on the rope by hand, keeping the coil together and considerable tension on the wire, winding over left to right as in Fig. 1, Plate No. 4.

2—Twist the ends of the wire together counter-clockwise by hand so that the twisted portion of the wires is near the middle of the seizing.

3—Using Carew cutters, tighten the twist just enough to take up the slack. Do not try to tighten the seizing by twisting.

4—Tighten the seizing by prying the twist away from the axis of the rope with the cutters, as indicated in Fig. 4.

5—Tighten the twist as in No. 3. Repeat 4 and 5 as often as is necessary to make the seizing tight. Cut off the ends of the wires and pound the twist flat against the rope.

6—The appearance of the finished seizing should appear as Fig. 6.

Any annealed low carbon steel wire may be used for seizings, the size ranging from No. 10 to No. 18, depending upon the diameter of the rope. This method is taken from the United States Government Master Specifications No. 297.

Socketing Wire Rope.

It is recommended for shaft hoist ropes that re-socketing be done about six times during the life of such ropes. This is necessary because at the attachment, the rope is subjected to the severest strains of vibration and to maximum corrosion elements. Generally speaking, ropes are not accorded the maintenance to which they are entitled. Operators are inclined to inspect superficially, records are seldom kept and resocketing is neglected. Complete replacement of a rope at stated intervals, regardless of visible condition is recommended in some cases. Because of

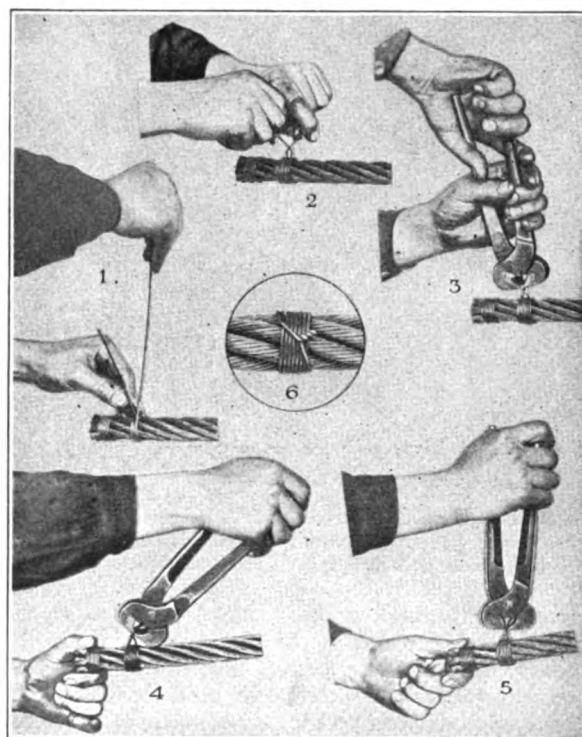


PLATE No. 4—Illustrated here is the proper method for seizing wire rope.

the expense, however, operators are wont to keep the line in service longer than the scheduled time, then hesitate to resocket it because they plan to abandon the rope in a short while. Such a policy may, and frequently does, lead to serious property damage and personal injury.

In socketing a wire rope, measure back from the end of the rope a distance equal to the length of the tapered basket of the socket. Tie securely at this

point with soft iron annealed wire and add two additional tie wires below the first.

Open up the strands as in Fig. 1 of Plate No. 5 and cut out the hemp core as far down toward the tie as possible. Unlay each wire and straighten so as to form a "brush" as in Fig. 2. On large ropes, it would be necessary to use a small pipe over each wire to straighten or approximately remove the curl from the wire.

If the wire is very greasy, hold the brush over a pail of gasoline, with the wires down, and wipe off the grease with waste or paint brush dipped in the gasoline. Wipe dry.

Dip the brush, holding the wires point down, into a pot of muriatic acid solution (50 per cent water, 50

light hammer while the zinc is still fluid, so as to jar the zinc into crevices between the wires. When cool, remove the fire clay and the serving wires, and the joint as in Fig. 6 will result. It will help slightly in the flowing of the zinc among the wires to put a small quantity of salamoniac crystals over the wires just prior to the pouring of the zinc.

Fig. 7 shows a phantom view of the zinc cone with imbedded wires.

There is no business or industry that has lowered its production costs to the irreducible minimum, and until this has been done, the greater amount of profit cannot be realized. Reduction of operating costs rests as much, if not more, in the smaller details, as it does in the major items of equipment. No superintendent ever contracts for a large investment without serious consideration. This is as it should be, but there are some who do not give proportional consideration to the minor items of equipment, notwithstanding that in the aggregate they represent a far greater investment than the larger single items. Only by paying constant attention to the little things can we hope to write larger figures on the right side of the ledger at the end of the year.

Ohio Brass to Have New Office Building

The much needed larger working quarters will be provided for the general offices of the Ohio Brass Company when the new administration building at Mansfield, Ohio, is completed. Construction work started October 1. The general offices at present are housed in the oldest building in the plant.

The new office building will cost approximately \$500,000. It is to be a five-story steel and brick structure with stone trim, 255 by 52 ft., and having reinforced concrete floors. Construction will be fireproof throughout. The general layout and appointments will compare favorably with the finest factory office buildings erected in recent years.

Provision is made for a 25 per cent increase in office force over present requirements, so that the company is planning well for the future.

Ample space will be provided officers and general sales officials and the seven divisions handling the sales of O-B products in the five industries served by this company. In addition there will be a permanent display room on the top floor. A conference room, seating 350, will be provided on the fifth floor, to be used for sales meetings and the like.

Extensive Improvements at Newport

Extensive additions have been made to the Newport Rolling Mill and The Andrews Steel Plant, allied industries in Newport. New offices just completed at the rolling mill, Ninth and Lowell Streets, Newport, cover nearly a half block. They were made necessary by enlargement of the organization which required additional space to house the executive department. The improvement involved an expenditures of \$85,000.

The site occupied by the new offices and quarters formerly was used as a garage, cafeteria, storehouse, time and employment office. The new cafeteria which is modern in every particular and a storehouse are also located on this site. In every department of the new offices are found innovations in keeping with the modern trend of American industry. In the employment office persons are examined carefully as to practicability.

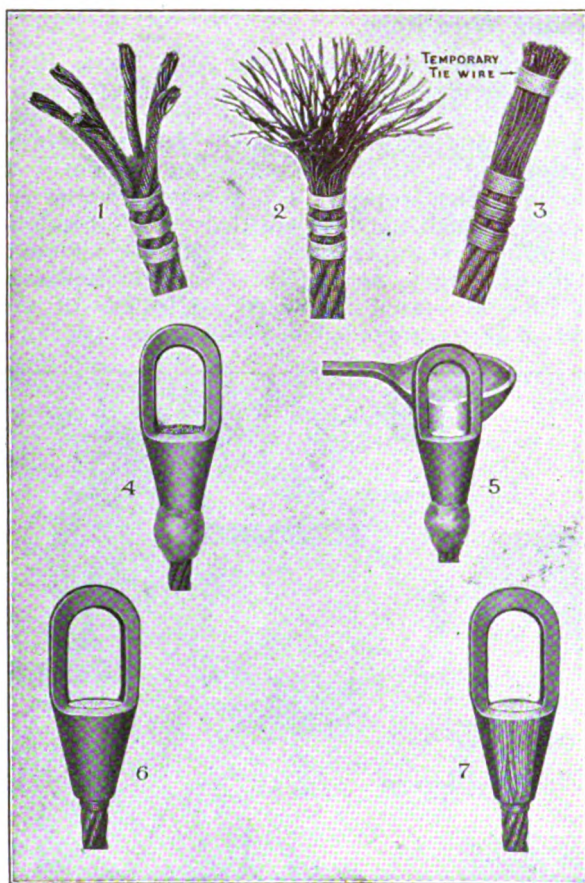


PLATE No. 5—How to resocket wire rope. Accompanying text gives full details of each successive step.

per cent commercial acid). Insert to a depth so as to not immerse the end of the hemp core. Keep in the acid until the wires are clean. Still holding the wires downward, withdraw from the acid and knock the rope sharply with a stick (broomstick or hammer handle).

Place a temporary tie wire, as in Fig. 3, over the ends of the brush, taking care not to handle the cleaned wires with greasy hands or tools.

Insert the rope end into the socket—then cut the temporary tie wire.

Set the rope vertically in a vise; set the socket so that the wires come flush with the top of the basket of the socket with the wires spread out; seal the bottom with clay or asbestos as in Fig. 4.

If cold, warm the socket moderately.

Pour with pure zinc, (not babbitt, lead or other alloy) as in Fig. 5. Tap the side of the socket with

Nature Studies—Iron Ores*

By R. H. DANZINGER

IRON, which is used for commercial purposes, is obtained by extracting it from ore. To classify it as an iron ore, depends upon the percentage of iron it contains, the amount of impurities and moisture present, and the cost of mining, transportation and smelting. It has been shown by scientists that the earth as a planet contains about $4\frac{1}{2}$ per cent by weight of iron.

Of the iron ore districts, the Lake Superior region in the United States is by far the most important in the world; from it is produced about 86 per cent of the iron ore output of the United States and about 40 per cent of the iron ore of the world.

The Lake Superior region has billions of tons of rock, which could be easily mined, containing from 30 to 40 per cent of iron in the form of hematite, which are not mined at present because there are in the same region hundreds of millions of tons of similar rock, which contain 50 to 68 per cent of metallic iron, from which pig iron can be made more cheaply.

Hematite, from a Greek word signifying "blood," is found in a number of varieties, but the one generally given this name is "Red Hematite," and contains 70 per cent iron in pure condition. It is the base of an important series of iron ores and is found in various shades of color, ranging from a deep red to a gray. This ore does not contain water in combination and, therefore, is sometimes called "anhydrous." Any moisture it may contain is driven off when the ore is heated to 212 deg. F.

"Puddlers ore" is a soft earthy variety of red hematite and is used in making up the bottoms of puddling furnaces. The hematite ores have been in great demand since the introduction of the Bessemer process of making steel, because of their usual freedom from phosphorus and sulphur. They are used in making

Bessemer pig iron for use in the acid Bessemer converter.

About 93 per cent of the iron ores mined and used in the United States are red hematites, and the production of the same in the U. S. A. from 1912 to 1926 exceeded about 800,000,000 tons.

Specularite is a hematite forming crystals of splendid luster.

Magnetite contains 72 per cent iron in pure condition. It is a black mineral, has a metallic luster and occurs in all conditions from loose sand to compact, coarse or fine grained masses. The production of magnetites in the U. S. A. from 1912 to 1926 exceeded about 30,000,000 tons.

Limonite or brown hematite is the name of a series of hydrated iron oxides which, in pure condition, contain from 60 to 65 per cent iron, and 8 to 20 per cent water chemically combined. Commercial brown hematite contains generally from 35 to 55 per cent iron. These ores have a dull luster and vary from a yellowish brown to black.

Turgite is nearly black and gives a brownish red streak on porcelain.

Goethite is a yellow, red or brown mineral in distinct crystals, often flattened, like scales, or needle like. It was this type of ore which characterized the very early iron

workings of the Atlantic coast colonies in Virginia and New England. Brown hematites are among the most important ones smelted in France and Germany. The production in the U. S. A. from 1916 to 1926 exceeded about 23,000,000 tons.

Siderite contains about 48 per cent of iron. It is of a gray or brown color, and has a glassy and sometimes a pearly luster. This form of ore is little used in the U. S. A., but quite extensively in England, Germany and Russia.

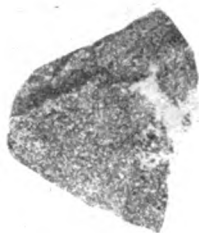
Impure forms are called "clay ironstones"; other forms are called "black band," "spathic" iron ore, "sphaerosiderite" and "niggerhead" ore.



PYRITES.



PYRITES.



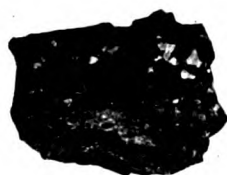
PYRITES.



LIMONITE.



LIMONITE.



MAGNETITE.



HEMATITE.



NEEDLE IRON ORE.



KIDNEY IRON ORE.



SPATHIC IRON ORE.



SPECULARITE.

*From "The Mixer," published monthly by the Joliet Works, Illinois Steel Company.

Coal Fields of the United States

The Author Covers the Coal Resources of the United States
in a Comprehensive Manner. Composition of Representative Coals From the Various Districts Given

By OLIN R. KUHN*

COAL in some form, like iron ore, is found in almost every quarter of the globe and is the most important mineral known as there is practically nothing produced in which coal does not enter in some part of the operation. The methods which nature used in storing away coal beds are not entirely clear but it is universally admitted that coal is entirely of vegetable origin. This vegetable matter under great pressure and heat, after thousands of years is slowly changed to coal. The various grades of coal blend together from lignite, the lowest form, to anthracite, the highest, and the grades, structure, etc., are vastly different in the various localities. Of course the use to which coal is put varies according to the chemical and physical structure. Some coals have coking qualities while others of practically the same character do not, but Table 1 gives roughly the grades of coal required for the different uses.

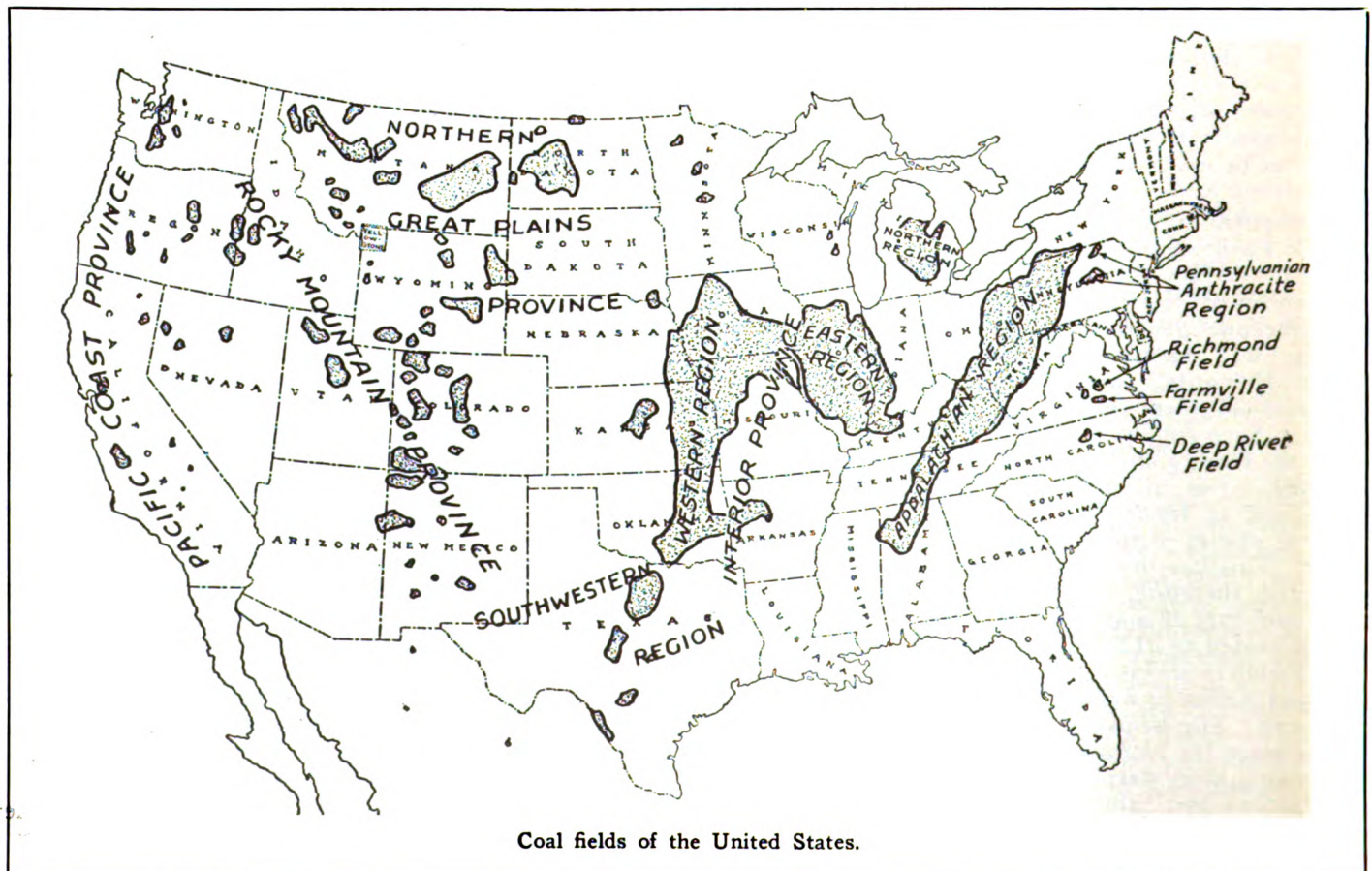
The United States of America contains about 50 per cent of the world's coal reserves and produces from 40 to 45 per cent of the total production. The bulk of the coal is a good grade bituminous coal although all grades from anthracite to lignite are found in the various parts of the country. The an-

thracite fields of Eastern Pennsylvania are the largest in United States and produce from 80,000,000 to 100,000,000 tons annually. The production of bituminous coal varies from 400,000,000 to 580,000,000 tons annually. The production of coal over the entire world averages from 1,250,000,000 to 1,500,000,000 tons per year. The coke produced in the United States varies from 35,000,000 to 55,000,000 tons annually requiring from 54,000,000 to 84,000,000 tons of coal.

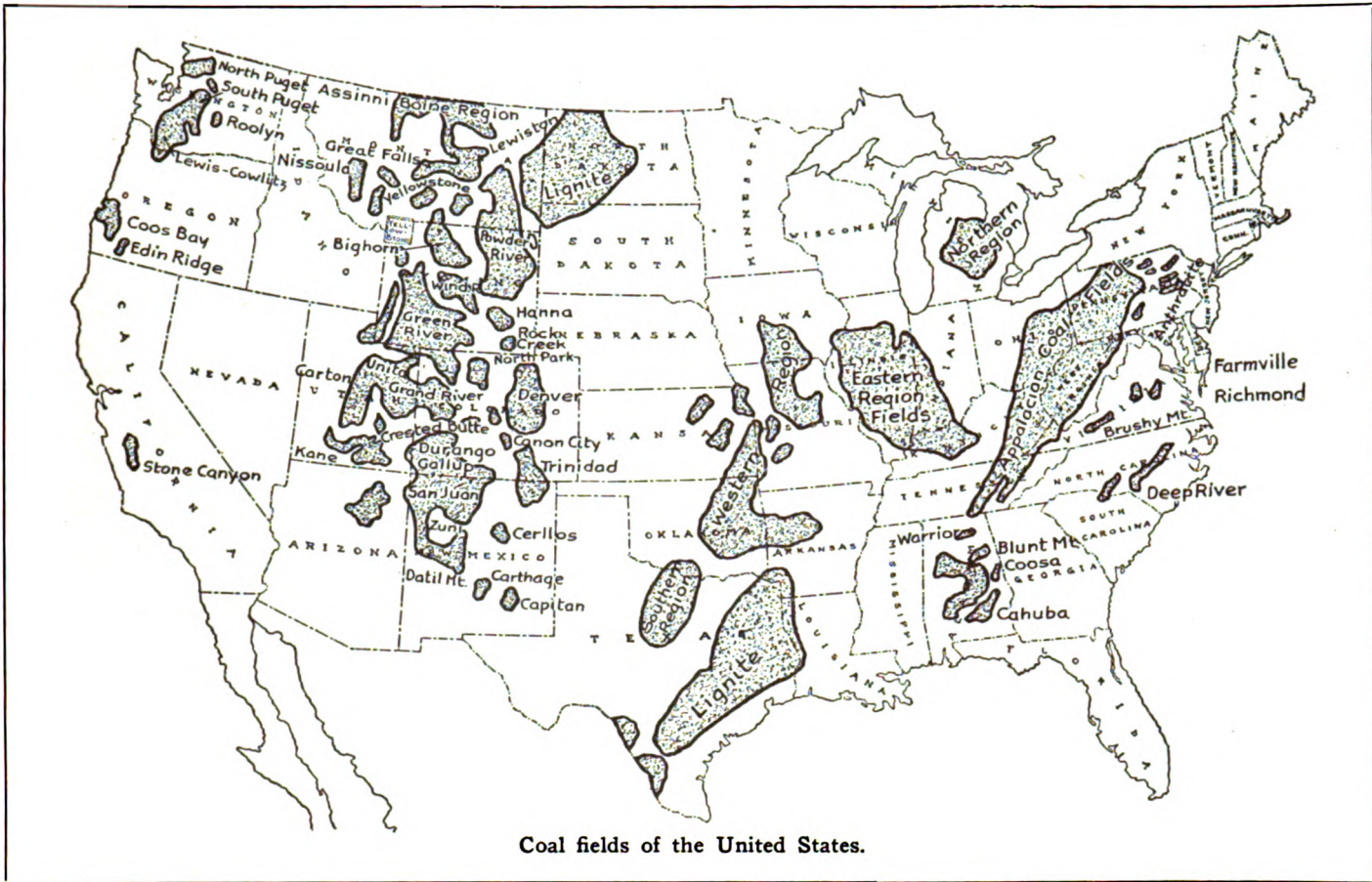
The coal fields of the United States are divided into six main provinces or districts; the Eastern, the Interior, the Southern, the Northern Great Plains, the Rocky Mountains, and the Pacific Coast. At the present time the Eastern Province, which includes the anthracite fields of Pennsylvania and the bituminous fields of the Appalachian Region, is by far the most important in the way of production and 70 per cent of all the coal mined in the United States comes from this district, 40 per cent of the coal is mined in the state of Pennsylvania alone. While the western provinces are not such large producers some of them contain vast reserves.

In describing the coal fields of the United States it would be impossible in the limited space to adequately describe them so I will merely mention the most important features of each state or district.

*Buffalo, N. Y.



Coal fields of the United States.



Alabama.

The coal formation of Alabama lies in the southern end of the Appalachian Region and is of the Carboniferous age, Pottsville group, of bituminous variety. The coal bearing area of this state is estimated at about 14,000 square miles around Birmingham and the reserve is put at 68,250,000,000 net tons. There are four mining districts, the Warrior, Blunt Moun-

tain, Coosa, and the Cahaba, and they produce from about 35 per cent volatile and the reserve is estimated at 60,000,000 tons, of which practically none has been mined.

Arkansas.

The workable coal in Arkansas covers an area of about 5,000 square miles. This field lies in the western

TABLE I
APPROXIMATE ANALYSES OF COALS FOR
VARIOUS PURPOSES

USE	VOLATILE	ASH	SULPHUR
Beehive coking....	32.00%	7.00%	Under 1.50%
By-product coking...	17 to 38	4 to 8	Under 1.50%
Cement burning...	Over 32.00	Long Flame	Over 12,000 Btu.
Domestic fuel....	Anthracite	Coke, or L. V.	Bituminous Coal
Illuminating gas...	32 to 37	6 to 8	Under 1.50
Melting (metallurgical fuel).....	High	.....	Low
Powdered coal....	30 to 36	Under 9.00	Under 1.25
Producer gas.....	High	Under 12.00	Under 2.00
Smithing	High Btu.	Low	Under 1.00
Tile and pottery burning	High	Low	Low
Locomotive fuel...		Various types of coal	

tain, Coosa, and the Cahaba, and they produce from 18,000,000 to 20,000,000 tons annually of medium volatile bituminous coal, 25 per cent of which goes into the manufacture of coke. The Warrior field is by far the largest and most important and contains 16 seams of coal varying in thickness up to 16 ft., but only the larger seams are mined.

Arizona.

Only a small area of some 30 square miles in Arizona is underlain with coal. This coal is of the sub-bituminous variety of Cretaceous age, carrying

COAL PRODUCTION OF THE UNITED STATES
AND THE WORLD—1905 TO 1924
In Thousands of Net Tons

Year	Anthracite Production	Bituminous Production	Total Production	Coke Production	World's Coal Production
1905	77,660	315,063	392,723	32,231	.....
1906	71,282	342,875	414,157	36,401	.....
1907	85,604	394,759	480,363	40,780	.....
1908	83,269	332,574	415,843	26,934	.....
1909	81,070	378,744	460,815	39,315	.....
1910	84,485	417,111	501,596	41,709	.....
1911	90,464	405,907	496,371	35,551	1,307,900
1912	84,363	450,105	534,467	43,984	1,373,900
1913	91,525	478,435	569,960	46,300	1,476,200
1914	90,822	422,704	513,525	34,556	1,327,700
1915	88,578	442,624	531,619	41,581	1,312,300
1916	87,578	502,520	590,098	54,534	1,420,100
1917	99,612	551,791	651,402	55,607	1,491,600
1918	98,826	579,386	678,212	56,478	1,466,300
1919	88,092	465,860	553,952	44,181	1,290,300
1920	89,598	568,667	658,255	51,345	1,450,900
1921	90,473	415,922	506,395	25,288	1,248,000
1922	54,683	422,268	476,951	37,124	1,248,000
1923	93,143	563,378	656,521	56,978	1,495,900
1924	87,742	462,670	570,412	43,463	1,489,700

part of the state and the coal varies from semi-anthracite to bituminous. There are six mining districts in this state which produce from 2,000,000 to 3,000,000 tons annually. There is one main seam in each district which averages from 2 to 8 ft. in thickness and

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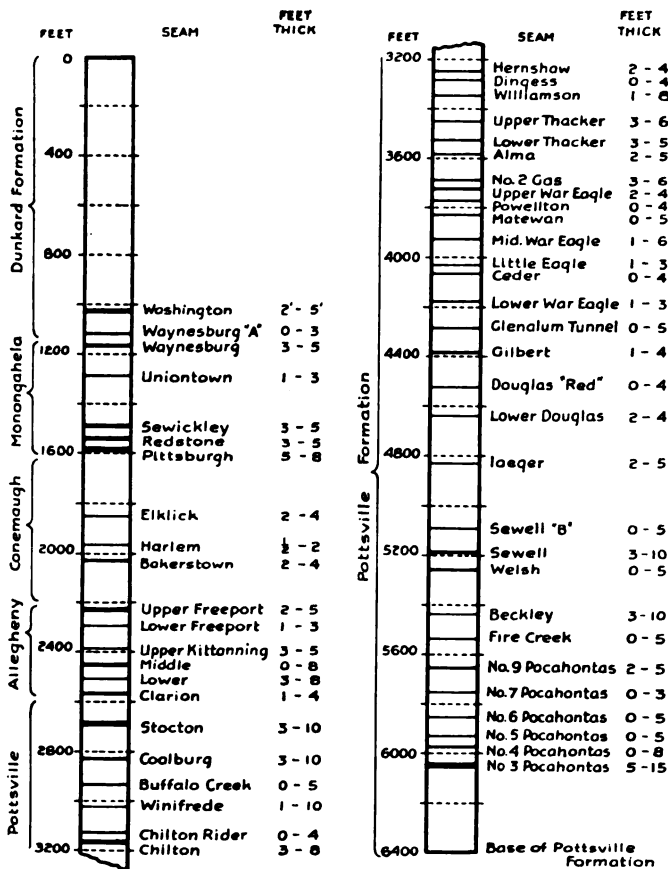
the total reserve of the state is put at 1,805,000,000 net tons. A deposit of lignite occurs in Ouachita County in the southern part of the state.

California.

The coal fields of California are scattered and the total workable area is only about 50 square miles. The coal, which is sub-bituminous and bituminous, is high volatile, but it is also high in ash and sulphur. The production of this state is only between 5,000 and 10,000 tons annually and the available reserve is estimated at 992,000,000 net tons.

Colorado.

Colorado is rich in coal reserves which underlie an area of 18,100 square miles. The reserve is estimated at 371,336,000,000 net tons but the production is only about 12,000,000 tons annually. There are nine coal fields in this state and all grades of coal from lignite to high grade bituminous are mined. There are from 2 to 16 seams in each of these fields which vary in thickness from a few inches to 15 feet.



Minable bituminous coal beds of West Virginia.

ated at 371,336,000,000 net tons but the production is only about 12,000,000 tons annually. There are nine coal fields in this state and all grades of coal from lignite to high grade bituminous are mined. There are from 2 to 16 seams in each of these fields which vary in thickness from a few inches to 15 feet.

Georgia.

The coal in Georgia is very similar to that in Alabama although the reserve is much smaller. The coal fields cover an area of only 167 square miles in the northwestern corner of the state and the reserve is estimated at only 977,000,000 net tons. Georgia produces about 70,000 tons of coal annually.

Idaho.

The workable coal in Idaho is sub-bituminous and covers an area of from 200 to 1,200 square miles. The reserve is put at 600,000,000 net tons from which practically none has been mined.

Illinois.

Illinois is the mainstay of the Interior Province district and produces from 80,000,000 to 90,000,000 tons of coal annually. The coal fields have an area of some 35,000 square miles and they belong to the Carboniferous age. The coal, which is high volatile bituminous, is used mainly for steam and domestic purposes, although mixed with the eastern coals it makes very good coke. The greater portion of the mining is done by the Room and Pillar method and the reserve is estimated at about 237,358,000,000 net tons. There are eight mining districts in Illinois and the coal seams vary from 3 to 14 ft. in thickness. Coal was reported in this district as far back as 1679 but it was not until 1810 that any coal was mined.

Indiana.

The coal measures of Indiana lie in the southwestern part of the state and cover an area of some 6,500 square miles. There are 34 different seams of coal in this state which vary up to 8 ft. in thickness but only the eight larger seams are worked. The coal is high volatile bituminous and the production averages from 25,000,000 to 30,000,000 tons annually. The reserve is estimated at 43,416,000,000 net tons. There is usually considerable sulphur present in these coals.

Iowa.

The coal fields of Iowa lie in the northern part of the Western Region and cover an area of about 19,000 square miles. There are 8 to 12 seams of coal in this district, some of them from 3 to 4 ft. thick. The coal which is sub-bituminous is high in sulphur and low in heating value and is only suitable for steam or domestic purposes. Iowa produces from 8,000,000 to 9,000,000 tons of coal annually and the reserve is estimated at 28,772,000,000 net tons. The Mystic seam is the most important in this field and averages about 30 inches in thickness.

Kansas.

The coals of Kansas underlie an area of some 20,000 square miles in the eastern part of the state. There are four main seams in this field which vary from 1 to 4 ft. in thickness and the coal is of low grade bituminous variety, quite high in ash and sulphur content. From 7,000,000 to 8,000,000 tons of coal are mined in Kansas annually and the reserve is put at 6,736,000,000 net tons. There are several bodies of lignite coals in the central part of the state.

Kentucky.

Kentucky contains two large coal fields, one in the eastern part of the state in the Appalachian Region and one in the west in the Eastern Interior Region. The coals of the Appalachian field are of high grade bituminous variety while those of the Interior field are of low grade, being of high sulphur content and low heating value. The eastern coal area covers an area of 10,270 square miles while the western area covers 6,400 square miles. Kentucky produces from 30,000,000 to 32,000,000 tons annually and the reserve is estimated at about 103,226,000,000 net tons. There are about 20 main seams of coal in this state which vary from 3 to 14 feet in thickness.

Maryland.

The coal deposits of Maryland are confined to the western part of the state between West Virginia and Pennsylvania and covers an area of about 450 square miles. The coal is high grade bituminous and is of the same measures as found in the neighboring states.

There are five main bodies of coal here and 9 or 10 major seams which vary from 1 to 22 ft. in thickness. Maryland produces from 4,500,000 to 5,500,000 tons annually and has a reserve of some 7,728,000,000 net tons. The Georges Creek district is probably the most noted in this state.

Michigan.

The Michigan coal basin covers an area of about 11,000 square miles in the center of the southern peninsula. There are five coal districts in Michigan containing about seven seams of workable thickness. The coal is of high volatile bituminous variety and the production is from 1,500,000 to 2,000,000 tons per year. The reserve of Michigan is estimated at 11,946,000,000 net tons.

Missouri.

The coal fields of Missouri are situated in the northwestern portion of the state and embrace an area of about 23,000 square miles. There are about 11 workable coal seams passing through the various coal districts in Missouri which vary from 18 inches to 6 ft. in thickness. The coal, which is high volatile bituminous, is inclined to be high in sulphur. The production of this state is about 5,500,000 tons annually and the reserve is put at 39,748,000,000 net tons.

Montana.

The coal bearing formations of Montana cover a scattered area of about 51,600 square miles and contain a reserve of about 302,942,000,000 net tons. This state produces about 4,500,000 tons of coal annually, most of which comes from Carbon, Musselshell, and Cascade Counties. The coals are medium volatile bituminous and sub-bituminous and there are about a dozen seams in these districts which vary from 2 to 15 feet in thickness.

New Mexico.

The larger coal fields of New Mexico are in the northwestern part of the state, called the San Juan River Region. The coal fields aggregate a total area of some 18,300 miles and the reserve is estimated at 163,659,000,000 net tons. New Mexico produces about 4,000,000 tons of coal annually most of which comes from the San Juan field. There are about six small coal fields scattered over the state and the workable coal seams vary from 2 to 7 feet in thickness.

North Carolina.

There are three small coal areas in North Carolina but they only cover an area of about 60 square miles and contain a reserve of 199,000,000 net tons. The production of this state has always been small and at present is only about 1,500 tons annually.

North Dakota.

The coal fields of North Dakota are of lignite rank and cover an area of some 35,500 square miles, most of which is in the western part of the state. The beds vary in thickness from 5 to 25 ft and occur at a depth of from 5 to 200 ft. There are no separate districts in this field and practically all of the beds are continuous and the seams are known only by local names. North Dakota produces from 750,000 to 800,000 tons of lignite coal annually and the reserve is put at 499,977,000,000 net tons.

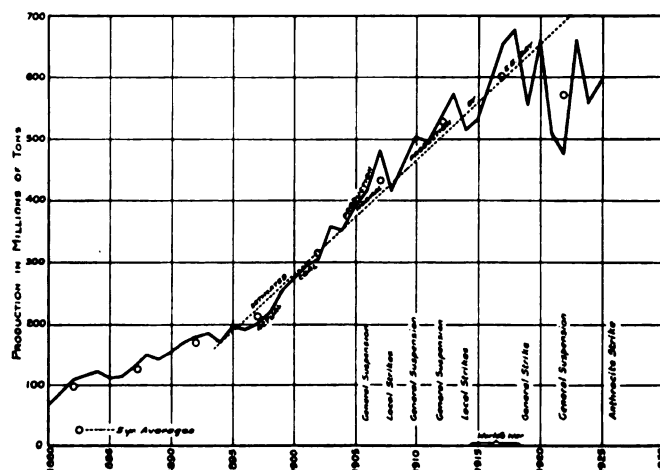
Ohio.

The coal fields of Ohio are in the eastern and south-eastern part of the state and embrace an area of some

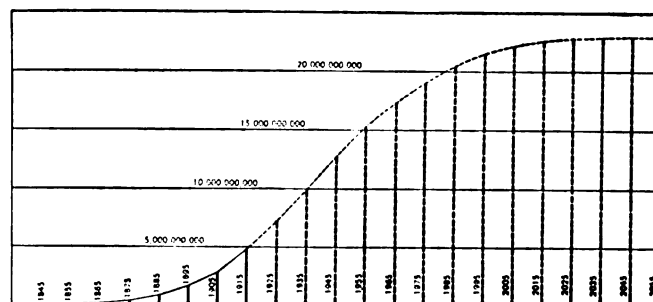
12,600 square miles. There are 10 mining districts in this state which contain 12 minable seams from 3 to 7 ft. thick. The coal is a good grade, high volatile bituminous and the production is about 46,000,000 tons annually. The reserve of Ohio is estimated at 84,429,000,000 net tons.

Oklahoma.

The coal beds of Oklahoma are in the eastern part of the state and cover an area of 10,000 square miles. The field is divided into two districts, the Cherokee, north of the Canadian River and the Cheetaw, south of the river. The coal beds of the Cherokee field occur in the upper coal measures and the coal is similar to that in Kansas. There are four workable seams of coal in the Cherokee field and seven in the Cheetaw



Coal production in United States 1880-1925 (net tons).



Production of coal in the United States by decades.
(E. W. Parker.)

field. The coal is all of good grade bituminous rank and the production averages about 5,000,000 tons annually. The reserve of this state has been put at 79,127,000,000 net tons.

Oregon.

The workable coal area of Oregon is estimated at 230 square miles and the reserve at 996,000,000 net tons. Oregon only produces less than 10,000 tons of coal annually most of which comes from Coos County and is of low grade bituminous rank.

Pennsylvania (Anthracite).

Operations in the anthracite field in eastern Pennsylvania date back to 1791 but it was not until 1820 that any real interest was shown in this field. The anthracite region embraces an area of about 3,300 square miles and the reserve at present is 12,820,000,000 net tons. There are four main districts in the

COAL RESOURCES OF THE UNITED STATES

State	Original Tonnage Thousand T.	First Record of Prod.	Production to 1923 Thousand T.	Estimated Exhaustion to 1925 Thousand T.	Reserve as of 1-1-25 Thousand T.	Record Production Year	Production Tonnage	Production for Year 1918
Alabama	68,903,000	1840	405,539	653,000	68,250,000	1917	20,608,074	19,184,962
Arizona	60,000	....	....	....	60,000	....	....	....
Arkansas	1,887,000	1840	52,284	82,000	1,805,000	1907	2,670,438	2,227,369
California	1,000,000	1861	5,516	8,000	992,000	1880	236,950	6,400
Colorado	371,770,000	1864	269,276	434,000	371,336,000	1917	12,483,336	12,407,571
Georgia	993,000	1860	10,284	16,000	977,000	1903	416,951	66,716
Idaho	600,000	....	....	....	600,000	....	....	....
Illinois	240,000,000	1810	1,601,279	2,642,000	237,358,000	1918	89,291,105	89,291,105
Indiana	44,169,000	1840	452,206	753,000	43,416,000	1918	30,678,634	30,678,634
Iowa	29,160,000	1840	248,392	388,000	28,772,000	1917	8,965,830	8,192,195
Kansas	7,022,000	1869	182,584	286,000	6,736,000	1918	7,561,947	7,561,947
Kentucky	104,027,000	1829	474,117	801,000	103,226,000	1918	31,612,617	31,612,617
Maryland	8,044,000	1830	207,809	316,000	7,728,000	1907	5,532,628	4,497,297
Michigan	12,000,000	1840	33,928	54,000	11,946,000	1907	2,035,858	1,464,818
Missouri	40,000,000	1840	159,822	252,000	39,748,000	1917	5,670,549	5,667,730
Montana	303,060,000	1880	72,343	118,000	302,942,000	1918	4,532,505	4,532,505
New Mexico	163,700,000	1881	73,453	121,000	163,659,000	1918	4,032,239	4,032,239
North Carolina	200,000	1840	600	1,000	199,000	1922	78,570	1,420
North Dakota (lignite)	500,000,000	1884	12,585	23,000	499,977,000	1922	1,327,564	719,733
Ohio	86,028,000	1838	985,898	1,599,000	84,429,000	1920	45,878,191	45,812,943
Oklahoma	79,278,000	1880	94,782	151,000	79,127,000	1920	4,849,288	4,812,943
Oregon	1,000,000	1880	2,420	4,000	996,000	1904	111,540	13,328
Pennsylvania (bitum.)	112,574,000	1840	4,109,706	6,540,000	106,034,000	1918	178,550,741	178,550,741
Pennsylvania (anth.)	19,500,000	1807	3,235,376	6,680,000	12,820,000	1917	99,611,811	98,826,084
South Dakota (lignite)	10,000,000	1910	112	....	10,000,000	1919	14,417	7,942
Tennessee	25,665,000	1840	175,800	279,000	25,386,000	1910	7,121,380	6,831,048
Texas (bitum.)	8,000,000	1884	44,497	73,000	7,927,000	1922	2,563,000	2,261,135
Texas (lignite)	23,000,000	....	....	....	23,000,000	....	....	....
Utah	196,458,000	1870	73,001	123,000	196,335,000	1920	6,005,199	5,136,825
Virginia	22,500,000	1822	181,143	302,000	22,198,000	1920	11,378,606	10,289,808
Washington	20,000,000	1860	92,841	147,000	19,853,000	1918	4,082,212	4,082,212
West Virginia	231,039,000	1863	1,521,599	2,522,000	228,517,000	1918	89,935,839	89,935,839
Wyoming	424,085,000	1865	177,718	291,000	423,794,000	1918	9,438,688	9,438,688
Alaska	15,104,500	1888	*250	500	15,104,000	1918	75,606	75,606
Total	3,170,906,500		14,957,061	25,269,500	3,145,637,000			678,211,904

*Balance included in California.

1½ tons exhaustion used per ton of coal mined in Bituminous coals and 2 tons in Anthracite.

anthracite field and the Mammoth seam is common to all of them. This seam varies from 14 to 50 ft. in thickness. Other seams vary from 2 to 18 ft. in thickness. Pennsylvania produces from 80,000,000 to 100,000,000 tons of anthracite coal annually.

Pennsylvania (Bituminous).

Pennsylvania is by far the largest producer of bituminous coal in the United States, mining from 150,000,000 to 180,000,000 tons per year, from 10 to 15 per cent of the world's total production of coal. The coal fields are in the western half of the state and cover an area of about 12,200 square miles. The coal is all of good grade bituminous and semibituminous rank and varies from 15 to 42 per cent in volatile matter. There are 20 different mining districts in Pennsylvania and about 16 workable coal seams which vary from 2 to 10 ft. in thickness. The main seams are the Pittsburgh, Sewickley, Freeports, and Kittannings. The reserve remaining in Pennsylvania is estimated at 106,034,000,000 net tons.

South Dakota.

The northwest corner of the state of South Dakota contains the southern extension of the North Dakota lignite beds which are estimated to cover about 6,000 square miles. Less than 10,000 tons of lignite per year are mined in this state and the reserve can be put at 10,000,000,000 net tons.

Tennessee.

The coal fields in Tennessee cover about 4,400 square miles in the east central part of the state and

the coal is very similar to that found in West Virginia and Pennsylvania, although not as of high quality. This field is divided into three districts, Northwestern, Northeastern, and Southern. The Northeastern district is by far the most important and contains about 18 seams of coal varying from 2 to 6 ft. in thickness. The other districts only contain two or three seams which average from 3½ to 4 ft. in thickness. The production of Tennessee is about 7,000,000 tons of coal annually and the reserve is estimated at 25,386,000,000 net tons.

Texas.

There are two main coal districts in the eastern and central part of Texas, one containing lignite and the other sub-bituminous coal. The lignite field covers an area of about 53,000 square miles and the reserve is estimated at 23,000,000,000 net tons, practically none of which has been mined. The sub-bituminous field includes an area of about 8,200 square miles and the reserve is estimated to 7,927,000,000 net tons. There are three workable coal beds in this field which vary from 2 to 4 ft. in thickness and the production averages from 2,000,000 to 2,500,000 tons annually. Two small fields of sub-bituminous coal are found in the southern part of the state on the Mexican border, but they are not worked to any great extent.

Utah.

The coal bearing measures of Utah cover an area of some 15,200 square miles and contain a reserve of about 196,335,000,000 net tons. The quality of the coal

ranges from sub-bituminous to anthracite and the production from 4,000,000 to 5,000,000 tons annually. In Carbon County, the most important mining district, there are from two to four workable seams of coal which vary from 5 to 28 ft. in thickness. The other districts contain low grade coal.

Virginia.

The coal areas of Virginia cover about 1,850 square miles and are separated into four districts, the Richmond, Farmville, Bushy Mountain, and Southern fields. Practically the entire production of the state, about 10,000,000 tons annually, comes from the southwestern field. The famous Pocahontas field of West Virginia extends down into the northern part of this district. There are nine workable coal seams in the Southern field which vary from 3 to 12 ft. in thickness. The Farmville field contains a number of small seams not over 2 ft. thick and the Richmond field contains

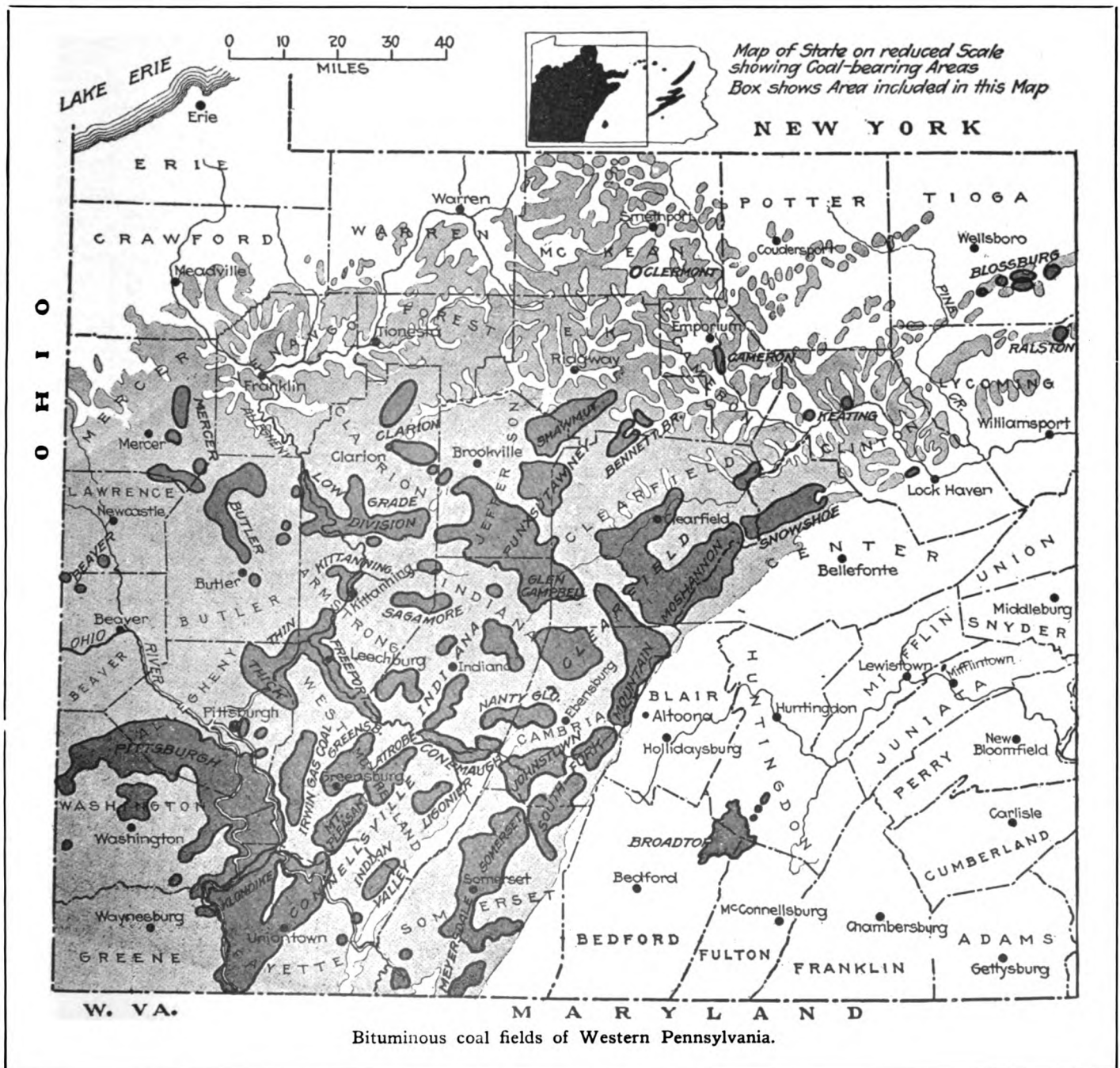
one bed averaging 20 feet in thickness. The Bushy Mountain field contains five seams but only two are workable. The reserve of Virginia is estimated at 22,198,000,000 net tons.

Washington.

The coal fields of Washington are in the western part of the state and embrace an area of 1,100 square miles. There are four large fields in this state and the reserve is estimated at about 19,853,000,000 net tons. The production of Washington is from 3,500,000 to 4,000,000 tons annually of semianthracite, bituminous, and sub-bituminous coal. These fields contain a number of coal seams but only a very few of workable thickness at present.

West Virginia.

The coal bearing area of West Virginia covers some 9,500 square miles and the reserve is estimated



ANALYSES OF REPRESENTATIVE COALS OF THE UNITED STATES

State and Field or District	Kind of Coal	Moisture	Volatile	Carbon	Ash	Sulphur	Btu.
Alabama—							
Warrior	Bituminous	2.3	29.7	58.0	10.0	1.0	13,500
Cahaba	Bituminous	3.2	31.0	59.0	6.2	1.0	13,800
Blunt Mountain	Bituminous	3.4	27.7	55.9	13.0	1.2	12,700
Coosa	Bituminous	2.4	33.3	60.0	4.3	1.1	14,650
Arizona—							
Black Mesa	Sub-bituminous	9.9	32.5	47.0	10.0	1.1	10,800
Arkansas—							
Huntington	Semi-bituminous	3.5	16.7	72.0	7.8	1.3	14,000
Jenny Lind	Semi-bituminous	1.6	17.4	73.1	7.9	2.8	13,800
Coal Hill	Semi-bituminous	1.4	14.8	76.9	6.9	1.5	14,300
Spadra	Semi-anthracite	1.7	10.5	79.5	8.3	2.5	13,900
Coaldale	Bituminous	6.8	25.8	43.4	24.0	2.3	.....
Paris	Semi-bituminous	2.8	14.7	73.4	9.1	2.8	13,800
Camden	Lignite	39.4	26.5	24.4	9.7	.5	6,400
California—							
Stone Canyon	Bituminous	7.0	46.7	46.1	6.2	4.2	12,500
Mt. Diablo	Sub-bituminous	15.0	38.4	34.5	12.1	5.6	9,200
Tesla	Sub-bituminous	18.0	39.2	26.4	16.4	3.1	8,100
Colorado—							
Trinidad	Bituminous	2.1	31.1	54.0	12.8	.6	13,100
Durango	Bituminous	2.7	36.1	54.5	6.7	.5	13,900
Canyon City	Bituminous	9.1	35.7	48.0	7.2	.9	11,700
Denver	Sub-bituminous	25.6	28.0	41.1	5.3	.4	9,200
Yampa	Anthracite	7.0	3.4	75.6	14.0	.6	11,900
North Park	Sub-bituminous	20.0	32.5	42.5	5.0	.6	9,750
South Platte	Sub-bituminous	26.2	29.7	37.7	6.4	.3	8,350
Grand River	Bituminous	9.4	38.0	45.4	7.2	.8	11,300
Yampa	Bituminous	10.4	37.9	45.5	6.2	.4	11,500
Crested Butte	Bituminous	5.6	37.6	47.6	9.2	.4	12,400
Georgia—							
Manlo	Semi-bituminous	2.9	17.1	72.2	7.8	.7	14,200
Idaho—							
St. Anthony	Bituminous	11.5	37.2	47.0	4.3	.5	12,100
Goose Creek	Lignite	34.3	26.6	25.4	13.4	2.5	8,600
Illinois—							
LaSalle	Bituminous	13.9	37.3	38.5	10.3	3.4	10,900
Danville	Bituminous	12.2	39.5	38.4	9.9	3.8	11,250
Peoria	Bituminous	12.7	35.5	40.2	11.6	4.2	10,650
Southwestern	Bituminous	12.7	36.4	41.4	9.5	3.7	11,000
Franklin	Bituminous	9.2	33.8	48.6	8.4	.9	11,900
Gallatin	Bituminous	3.4	35.2	52.5	8.9	2.9	13,200
Indiana—							
Southern	Bituminous	9.7	35.4	44.5	10.2	2.9	11,450
Brazil	Bituminous	15.4	32.6	46.1	5.9	2.0	11,700
Iowa—							
Boone	Bituminous	19.5	33.4	38.3	8.8	5.4	10,500
Centerville	Bituminous	17.1	35.4	40.4	7.1	4.0	10,900
Kansas—							
Levenworth	Bituminous	12.0	35.2	39.1	13.7	4.4	10,700
Scranton	Bituminous	6.7	35.6	50.5	7.2	4.3	10,900
Columbus	Bituminous	5.1	32.6	53.4	8.9	4.3	12,900
Kentucky—							
Hazard	Bituminous	3.9	37.2	54.8	4.1	.8	13,700
Paintsville	Bituminous	6.4	36.2	54.1	3.3	1.2	13,500
Morganfield	Bituminous	3.9	37.1	49.7	9.3	3.5	12,800
Owensboro	Bituminous	11.8	36.8	42.0	9.4	3.3	11,150
Maryland—							
Georges Creek	Semi-bituminous	.6	17.7	73.0	8.7	1.4	14,000
Upper Potomac	Semi-bituminous	1.7	19.0	68.1	11.2	1.6	13,450
Castleman	Bituminous	.7	24.0	66.8	8.5	1.4	13,950
Upper Youghiogheny	Bituminous	1.2	23.0	63.9	11.9	2.1	13,250
Lower Youghiogheny	Bituminous	2.3	25.5	64.4	7.8	1.1	13,800
Michigan—							
Saginaw	Bituminous	11.9	31.5	49.8	6.8	1.2	11,800
Lansing	Bituminous	7.0	39.1	46.4	7.5	3.4	.....
Jackson	Bituminous	5.6	46.7	45.3	2.4	2.8	13,550
Owosso	Bituminous	.4	32.9	28.7	42.9	7.7	.....
Missouri—							
Vernon	Bituminous	6.5	32.6	50.8	10.1	5.0	12,450
Henry	Bituminous	10.6	37.2	40.7	11.5	3.6	11,250
Ray	Bituminous	15.8	32.8	41.5	9.9	3.0	10,600
Boone	Bituminous	10.8	33.6	42.4	13.2	5.1	10,850
Adair	Bituminous	15.4	34.8	38.8	11.0	3.6	10,450
Montana—							
Trial Creek	Bituminous	12.4	36.8	42.3	8.5	.6	10,950
Missoula	Lignite	24.7	29.3	26.1	19.9	.9	6,750

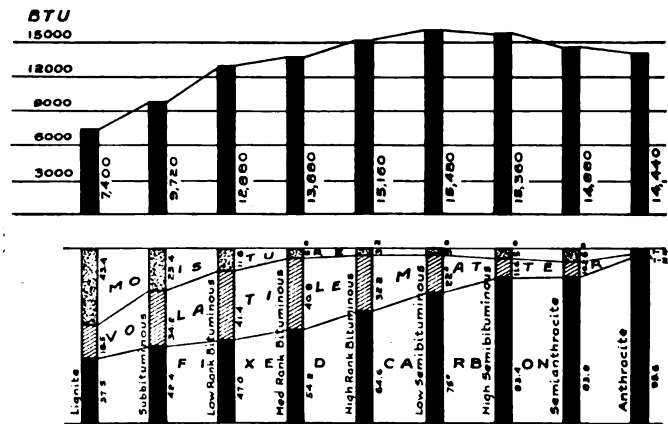
ANALYSES OF REPRESENTATIVE COALS OF THE UNITED STATES—Continued

State and Field or District	Kind of Coal	Moisture	Volatile	Carbon	Ash	Sulphur	Btu.
Montana (Continued)—							
Red Lodge	Sub-bituminous	11.7	36.1	40.2	12.0	1.1	9,800
Bull Mountain	Sub-bituminous	17.5	31.2	45.1	6.3	.5	10,100
Lewiston	Bituminous	12.7	29.6	48.8	8.9	3.7	10,900
Great Falls	Sub-bituminous	12.1	34.7	41.7	11.5	.8	9,600
Electric	Bituminous	4.0	22.5	59.3	14.2	.6	12,750
Miles City	Lignite	29.2	26.2	35.4	9.2	.8	7,650
Assiniboine	Sub-bituminous	25.6	27.9	39.2	7.3	.6	8,300
New Mexico—							
Raton	Bituminous	2.1	36.1	50.2	11.6	.6	12,950
Los Cerrillos	Bituminous	3.2	41.4	44.4	11.0	1.6	12,450
Los Cerrillos	Anthracite	5.7	2.2	86.1	6.0	.7	13,250
Carthage	Bituminous	3.0	38.0	51.6	7.4	.9	13,250
Capitan	Bituminous	2.5	34.6	46.0	16.9	.8	11,950
Zuni	Sub-bituminous	12.7	36.5	43.3	7.5	.7	11,250
Monero	Bituminous	3.0	39.0	48.3	9.7	3.5	12,950
North Dakota—							
Adams	Lignite	32.4	30.9	28.1	8.6	1.5	7,350
Williams	Lignite	41.1	27.2	26.3	5.4	.7	6,500
Ohio—							
Mahoning Valley	Bituminous	3.8	39.1	50.3	6.8	3.1	13,000
Massillon	Bituminous	7.3	34.9	53.6	4.2	1.0	12,500
Bellaire	Bituminous	3.0	37.6	49.5	10.0	3.7	12,950
Cambridge	Bituminous	5.4	39.9	49.6	5.1	3.2	12,950
Meigs Creek	Bituminous	3.4	37.9	49.1	9.6	5.1	12,750
Hocking Valley	Bituminous	3.2	45.1	46.8	4.8	3.3	13,750
Pomeroy	Bituminous	8.1	37.5	45.9	8.5	3.6	12,100
Wellston	Bituminous	7.5	36.4	54.9	1.2	.7	11,500
Ironton	Bituminous	8.4	35.2	49.0	7.4	2.7	12,200
Crookston	Bituminous	5.0	39.8	47.4	7.8	4.8	12,550
Oklahoma—							
McAlester	Bituminous	4.6	37.0	47.3	11.1	3.6	12,300
Henryetta	Bituminous	7.0	34.5	48.4	10.0	1.9	12,200
Wilburton	Bituminous	3.0	35.9	55.9	5.1	1.0	13,700
Lehigh	Bituminous	6.2	37.3	43.3	13.2	4.0	11,200
Tulsa	Bituminous	6.3	37.7	47.8	8.2	8.2	12,700
McCurtain	Semi-bituminous	2.4	19.2	69.5	8.8	1.0	13,850
Poteau	Semi-bituminous	.2	23.5	66.2	10.1	4.3	.....
Howe	Semi-bituminous	5.1	15.8	72.5	6.6	.7	.....
Oregon—							
Coos Bay	Sub-bituminous	18.0	31.8	39.7	10.5	2.2	8,900
Eden Ridge	Bituminous	12.6	35.0	37.7	14.7	1.3	10,350
Pennsylvania—							
Eastern	Anthracite	2.2	5.7	86.2	5.9	.6	13,850
Blossburg	Semi-bituminous	.8	20.9	65.5	12.1	.7	.....
Snowshoe	Bituminous	3.5	23.7	61.6	11.2	2.7	13,050
Clearfield	Semi-bituminous	3.3	19.9	69.0	7.8	2.0	14,000
Clearfield	Bituminous	2.8	24.3	66.2	6.6	.9	14,100
Reynoldsville	Bituminous	1.6	34.5	57.4	5.5	1.1	.....
Low Grade Division	Bituminous	2.7	34.8	52.2	10.3	2.7	.....
Shawmut	Bituminous	2.7	33.7	54.9	8.7	2.9	13,450
Cambria	Semi-bituminous	3.3	12.5	77.9	6.3	1.0	14,350
Cambria	Bituminous	3.1	26.0	64.4	6.5	1.4	14,150
Two Lick	Bituminous	3.5	23.1	67.2	6.3	1.0	14,050
Indiana	Bituminous	1.0	26.1	63.8	9.1	2.7	13,950
Allegheny River	Bituminous	.8	35.7	51.1	11.6	.6	.....
Johnstown	Semi-bituminous	4.4	19.2	68.8	7.5	1.8	13,700
Southfork	Semi-bituminous	2.4	14.3	71.4	11.9	3.3	13,300
Quemahoning	Bituminous	2.8	16.1	73.6	7.5	.8	14,000
Broadtop	Semi-bituminous	2.1	15.5	76.0	6.4	1.1	14,450
Meyersdale	Semi-bituminous	3.0	19.6	70.3	7.0	.7	14,150
Latrobe	Bituminous	4.0	28.1	57.7	10.1	1.0	13,350
Greensburg	Bituminous	3.2	30.3	56.2	10.4	1.3	13,400
Youghiogheny	Bituminous	11.	34.0	54.4	9.5	1.1	.....
Connellsville	Bituminous	2.8	30.0	59.8	7.4	1.2	14,000
Pittsburgh	Bituminous	1.4	34.6	57.8	6.2	.8	14,250
South Dakota—							
Harding	Lignite	41.5	24.0	24.3	10.2	.6	5,650
Tennessee—							
Huntsville	Bituminous	3.8	38.5	51.2	6.2	1.9	13,400
Harriman	Bituminous	4.3	25.7	62.5	7.5	.6	13,650
Tracy City	Bituminous	3.4	28.2	60.1	8.3	.8	13,450
Texas—							
Central	Sub-bituminous	13.4	34.8	36.4	15.3	2.5	9,600
Eagle Pass	Sub-bituminous	9.4	33.1	40.1	17.4	1.3	11,150
—Laredo	Cannel	2.5	45.3	29.3	22.9	2.4	10,900
Wood County	Lignite	28.9	35.9	27.3	7.9	.5	8,000

at 228,517,000,000 net tons. There are 11 mining districts in this state which include 102 coal seams, 52 of which are minable, although only about 24 are worked at present. Some of the purest coals in the world come from this state and about 90 per cent of the entire production, 75,000,000 to 90,000,000 tons annually, is shipped out of the state. The coal seams vary up to 15 ft. in thickness and the coal is bituminous and semi-bituminous, varying from 13 to 45 per cent in volatile matter.

Wyoming.

Coal bearing rocks underlie an area of about 50,800 square miles in Wyoming but the majority of the coals, which are estimated at 423,794,000,000 net tons, are of sub-bituminous or lignite rank. There are four main coal districts in this state, Bighorn, Power River, Wind River, and Green River, and the bulk of the coal is mined in eight counties. The coal beds



Various types of coal found in the United States. Diagrams showing the chemical and heat efficiency of the several ranks of coal found in the United States—ash free basis.

vary in thickness up to more than 22 ft. and the production from 8,000,000 to 9,500,000 tons annually.

Alaska.

The coal bearing areas of Alaska cover about 1,200 square miles and the reserve is estimated at 15,104,000,000 net tons, but much of the country is still unexplored. The coal fields may be considered as the Pacific Slope fields, the Central Region fields, and the Northern fields, and the predominate coals are of lignite and low grade bituminous rank. Alaska never produced much coal but in 1918 the production reached 75,606 tons. The seams vary up to 30 feet in thickness.

Reserve.

It is estimated by the Geological Survey that some 496,750 square miles in the United States is underlain

by workable coal beds and careful estimates have been made of the quality and the quantity of the coals in the various fields. The estimates of the original tonnage of coal was put at about 3,170,906,000,000 net tons and the exhaustion to January, 1925 amounted to about 25,269,000,000 tons, leaving a reserve of about 3,145,637,000,000 net tons. Other estimates are as high as 4,231,352,000,000 tons so that the figure given above is probably very conservative. The International Congress in 1913 put the total coal resources of the world at 8,154,322,000,000 tons of which the United States contained about half.

VARIOUS ESTIMATES OF THE UNITED STATES COAL RESERVE

Estimated by	Year	Tonnage
U. S. Geological Survey, No. 394...	1909	3,170,906,000,000
Twelfth International Congress....	1913	4,231,352,000,000
U. S. Fuel Administration.....	1915	3,538,554,000,000
U. S. Geological Survey.....	1919	3,535,691,000,000
O. R. Kuhn*.....	1925	3,145,637,000,000

*Geological Survey figures with exhaustion to date.

Duration of Reserve.

Assuming the reserve to be 3,145,637,000,000 net tons as given above and an exhaustion of 1½ to 1, would give a reserve of actual available coal of about 2,100,000,000,000 tons. If this coal was mined at the rate it was in 1918, the record production, it would not be exhausted for 4,640 years, but the production of coal in the United States has steadily increased over the last 90 years and it is only logical to assume that this increase will continue, at least for some years. Of course, there will come a time when the maximum production will be reached and this will probably hold stationary for a time before it decreases, due to the mining of the thinner beds, the depths of the shafts, increased cost of mining and haulage, etc. The chart on page 469 by E. W. Parker (1908) gives the estimated production of coal in the United States by decades for the next 130 years or until 2055. According to his calculations the maximum production of 4,600,000,000 tons annually would be reached in about 100 years. The Geological Survey estimate that the high grade, easily accessible coal will be exhausted in from 50 to 100 years but that it will be much longer before our coal reserves are depleted. The development of water power, substitutes, electricity, economies in mining, etc., will all affect the length of life of our coal reserves, so that it is practically impossible to estimate the date of exhaustion of our coal resources except to say that it will be some place between 100 and 4,000 years, probably closer to the former.

TYPE CLASSIFICATION OF COALS

Analysis—Ash Free	Anthracite	Semi-Anthracite	Semi-Bituminous	Bituminous	Sub-Bituminous	Lignite
Fixed carbon, per cent.....	96	84	79	54	42	38
Volatile	1	10	17	40	34	19
Moisture	3	6	4	6	24	43
Btu.....	14,400	14,900	15,400	13,900	9,700	7,400
Character	Hard	Hard	Friable	Soft	Soft	Soft
Color	Black	Black	Black	Black	Black	Brown
Flame	Short	Short	Short	Medium	Long	Long
Smoke	Smokeless	Nearly Smokeless	Smoky	Smoky	Smoky	Smoky
Storage	Stores Well	Stores Well	Fairly Well	Slacks	Slacks	Slacks

*From the United States Geological Survey.

Maintenance and Repair of Commutators

Undercutting of Commutator Is Advisable to Prevent Poor Commutation, Wearing Down and Burning of Brushes and Commutator, and Friction Losses.

By EARL B. STAVELY*

THE first section of this article (see Modern Mining, September, 1926) included a discussion of methods which should be employed in sanding, stoning, grinding, and turning commutators and brief reference to certain other facts which should be considered in the maintenance and repair of commutators. Other facts of equal importance will be discussed in this the concluding section of the article.

Undercutting.

A commutator is "undercut" by cutting down the mica between bars to a depth of about $1/32$ inch. This process produces a small slot between adjacent bars, hence the process is called "slotting."

Commutators are undercut chiefly for three reasons: (1) Poor commutation resulting from high mica, and the accompanying burning of brushes and commutator, is eliminated; (2) the wearing down of the commutator bars and brushes is reduced, thereby increasing the life of these parts; (3) the friction losses and heating at the commutator and brushes are reduced.

The presence of the slots between bars increases the probability of trouble due to short circuits between bars, but the causes of this trouble can be easily eliminated by proper maintenance as will be noted later. Undercutting is so desirable, for the reasons previously noted, that undercutting of commutators is today considered standard practice by most electrical manufacturers. For the same reasons those who are responsible for the operation of electrical machinery have often found it desirable, or even necessary, to undercut the commutators of older machines which originally had flush mica. The advantages of undercutting deserve careful consideration, hence these will be discussed briefly before proceeding further.

Advantages of Undercutting.

Sparking at the brushes, even though this is so slight that it does not appear to be serious, causes a burning away of the copper bars of the commutator. The mica, due to its heat resisting qualities, is not burned away, however, hence after a time the mica projects above the surface of the bars. It is then impossible for the brushes to make good contact with the commutator bars and the current arcs across the small gap between the brush face and the bars. The sparking is thus made much more serious and the burning away of the bars is greatly increased. The action is cumulative, the sparking continually becoming more serious, and soon it is found necessary to take the machine out of service and turn down the commutator face.

In attempting to eliminate this cause of trouble brushes are sometimes used which are sufficiently abrasive to wear down the mica at the same rate that the copper is burned away. This, however, is a rem-

edy which provides only temporary relief instead of removing the cause of the trouble. Undercutting, on the other hand, is an effective remedy since it at once eliminates the possibility of the development of high mica and the troubles resulting from it.

As just noted, brushes of rather high abrasive qualities must generally be used on commutators having flush mica. Brushes having very little abrasive action are usually satisfactory with undercut commutators, abrasive action being required here only in case it is found impossible to prevent burning and blackening of the commutator face. This burning is found in machines subject to considerable vibration and in machines which are required to carry heavy overloads during short but frequent intervals. Abrasive action of the brushes is required in such cases to remove the burned surface of the bars and thus maintain good electrical contact between bars and brushes.

The slight abrasive action of the brushes which are suitable for use on undercut commutators results in considerable less wearing down of the commutator than is found in machines having flush mica and abrasive brushes. The useful life of the commutator is accordingly increased.

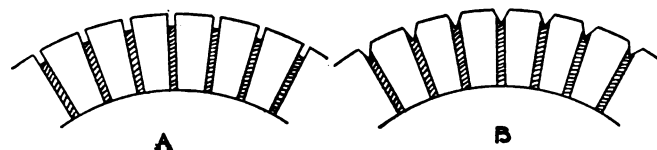


FIG. 1—Types of slots formed when undercutting commutators. (A) Square bottom slot. (B) V-shaped slot.

Due to the absence of marked abrasive action of the brushes an undercut commutator usually develops a more polished surface than a commutator with flush mica. The brushes are, therefore, worn down at a lower rate and brush renewals must be made at less frequent intervals.

The abrasive brushes required on commutators having flush mica cause more friction loss than is found in undercut machines with non-abrasive brushes. This friction loss makes itself evident in the form of heat which causes the temperature of the brushes and commutator to rise. Undercutting, together with the use of brushes of proper grade, should, therefore, decrease the commutator losses and temperature rise for a given condition of loading. For the same reasons, this may appreciably affect the ability of the machine to carry sustained overloads without serious overheating of the commutator.

Undercutting, while desirable for the reasons just noted, must be carefully and properly carried out, otherwise operating conditions may be made worse instead of being improved. For this reason methods of undercutting will be discussed in some detail here.

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Shape of Slots.

Slots of two different types, or shapes, may be formed when undercutting commutators. These types are the "square bottom" and the "V". The difference between these two types is shown in Fig. 1.

The slots of undercut commutators should be "self cleaning," that is, particles of copper and carbon dust, dirt, etc., should be thrown from them by the rotation of the commutator. Slots which do not thus clean themselves quickly fill up with dust and dirt. If this dirt is not frequently removed serious trouble will eventually develop. Ring fire, "flashing over," short circuits between bars, and overheated armature coils are a few of these troubles.

Slots with square bottoms, and a depth of $1/32$ inch, usually prove self cleaning to a satisfactory degree when the surface speed of the commutator is not less than about 4,000 feet per minute and when oil and grease are kept away from the commutator and brushes. Slots which are $3/64$ inch deep do not generally prove self cleaning if the surface speed of the commutator is less than about 5,000 feet per minute.

The V-shaped slot is usually self cleaning with commutator surface speeds as low as 1,000 feet per minute.

Few machines have a surface speed lower than 1,000 feet per minute, hence the V-shaped slot proves satisfactory under practically all conditions. The square bottom slot should not be used, on the other hand, if the speed is less than about 4,000 feet per minute. This limits the application of the square bottom slot to high speed turbine driven generators, converters, and special motors.

The V-shaped slot is recommended for all machines, regardless of commutator surface speed, due to its more positive self cleaning action.

Depth of Slots.

Square bottom slots should not be deeper than $3/64$ inch, but should be at least $1/64$ inch deep. A depth of $1/32$ inch is recommended for average conditions.

V-shaped slots which are cut with an angle of from 50 to 60 deg. have proven most satisfactory. Slots with an angle of only 40 deg. are generally used in case the mica is quite thin.

The depth of V-shaped slots will vary with the thickness of the mica between bars, but the depth should fall within the limits given previously for square bottom slots.

Improper Methods of Undercutting.

It might appear, at first thought, that satisfactory undercutting may be carried out by any method whereby the mica is cut down below the surface of the bars. Improper methods of undercutting, based upon an assumption such as this, are the cause of many serious commutator troubles.

The most common of these improper methods involve the use of some type of raking tool which has but one cutting edge. Hand tools of this type are sometimes used; in other cases the armature is swung in a lathe and the mica is undercut by a raking tool mounted in the tool rest.

Mica plate, which is used as insulation between commutator bars, is built up of thin flakes of mica which are held together by a suitable binding varnish.

This mica plate, while hard, is rather brittle. A raking tool, even though used with great care, will cause cracks in the mica as shown in Fig. 2-a, and a ragged, rather than a smooth, slot as shown in Fig. 2-b. Dirt, moisture, oil and grease readily penetrate mica plate in this condition, hence mica thus undercut eventually breaks down electrically and must be replaced.

These results may be avoided in some cases by filling the slots cut by raking tools with a suitable varnish or cement. It is strongly recommended, however, that the use of all types of raking tools with but one cutting edge be avoided.

Commutator Slotting Files.

Slotting files are available in a variety of types. These are designed to produce a V-shaped slot. Undercutting with these files requires considerable time and labor, but their use is recommended in cases where only a comparatively small amount of undercutting is to be done. Power driven undercutting machines, which will be described later, are recommended in case a large amount of undercutting must be carried out.

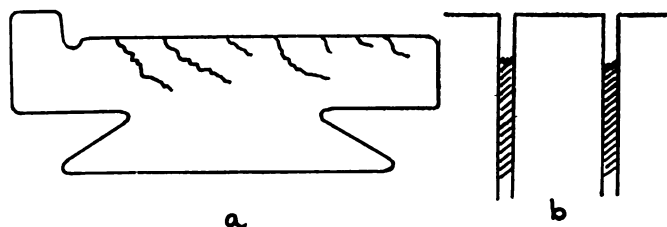


FIG. 2—Results of using raking tool when undercutting commutator mica. (a) Cracks in mica. (b) Ragged mica at bottom of slot.

Commutator slotting files may be obtained in a variety of lengths and angles. Files equipped with offset handles are most convenient to use, even though some men prefer the simple double end files.

A 40-deg. angle file is recommended for undercutting thin mica, and 60-deg. files for the mica commonly used in most commutators.

Commutator Slotting Machines.

Various types of power driven slotting machines are available. These types differ considerably in certain design features and slightly in the method of application. All types consist essentially, however, of a small circular disc cutter which is motor driven (through a flexible shaft, for example), and mounted in a suitable frame. Other important features include adjustable guides which regulate the depth of the slot, adjustable guides which ride in adjacent slots and thus guide the cutter as it is moved across the commutator, suitable handles by which the machines are manipulated, and provision for forcing a blast of air along the edge of the cutter, thereby removing mica and dust from the slot and enabling the operator to follow the work more closely.

These slotting machines may be equipped either with saws or milling cutters. The saws produce a square bottom slot; the milling cutters produce a V-shaped slot. The use of the milling cutters is recommended since they give the more desirable type of slot.

Use of Slotting Machines.

In machine undercutting with one of these saws care should be taken to select a saw of a thickness

suitable for the mica which is to be undercut. The saw should be about 0.002 inch thinner than the mica. The saws are manufactured in thicknesses which conform in this way to the thickness of the standard mica plate used in commutators.

It is practically impossible to prevent cutting the sides of the bars even though the saw used is slightly thinner than the mica. This cutting hardens the copper at the sides of the bar, hence when the commutator is surfaced after undercutting, either with sandpaper or a commutator stone, a sharp edge is produced at each side of the slot. Due to the presence of these sharp edges the brushes are worn down rapidly and the slots may become filled with carbon dust and cause troubles which were mentioned previously.

It is also practically impossible to cut a slot which will not leave, at certain points, a thin piece of mica as shown in Fig. 3-a. The presence of this mica leads to the development of troubles associated with high mica, hence the slotting is of doubtful value if the commutator is left in this condition.

These troubles, due both to sharp edges on the bars and to mica on the sides of the slots, can be eliminated easily by simply rounding the edges of the bars as indicated in Fig. 3-b. This can be done with a commutator file, or ordinary three-cornered file, or a hand scraping tool of proper shape.

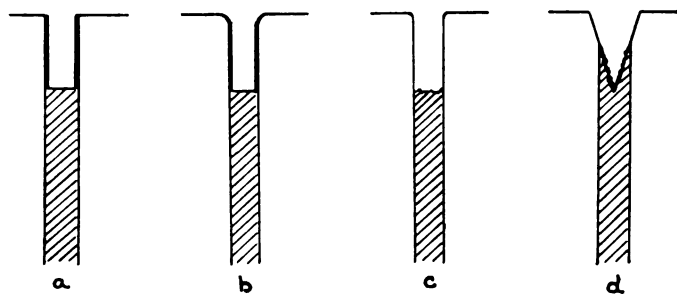


FIG. 3—(a) Mica remaining at sides of slot after undercutting. (b) Defect shown in (a) eliminated by rounding edges of bars with a file or scaper. (c) Ragged mica at bottom of square slot. Mica should be smooth as at bottom of slot in (b). (d) Ragged mica at sides of V-shaped slot. Mica should be smooth if penetration of moisture and grease is to be avoided.

The V-shaped slots produced by the use of milling cutters are shown in Fig. 3-d. If the slotting is properly done there will be no mica left flush with the commutator surface. The hardening of the copper due to the cutting action of the cutter tends to produce a sharp edge at the sides of the bars as is the case when saws are used. This effect is not so pronounced here, however, but it is well to round the edges slightly in case they feel sharp.

After Undercutting.

The commutator should be carefully examined after the undercutting is completed, and if the slotting appears to have been satisfactorily carried out the commutator surface should be polished with sandpaper or a commutator stone. A final inspection should then be made after the slots have been cleaned. In this inspection the writer always uses a hand glass or small magnifying glass, together with a strong light, in order that the condition of each slot may be accurately determined. No mica should be flush with the surface. The edges of the bars should be rounded.

The mica at the bottom of square slots, and at the sides of V-shaped slots, should be cut clean and smooth. The slot should be free from copper dust. Ragged mica, as shown in Fig. 3-c and Fig. 3-d, will quickly accumulate dirt, grease and moisture.

Selection of Brushes.

It should be noted again that a change in brushes is necessary when a commutator with flush mica is undercut. The brushes used on machines with flush mica are of the abrasive type, as noted previously. If these brushes are left on the machine after undercutting, the copper bars will be worn down at a rapid rate, copper dust may accumulate in the slots, and short circuits may develop between bars. Even though this trouble does not arise, this unnecessary wearing down of the bars reduces the useful life of the commutator.

Brushes of little abrasiveness should be used on slotted commutators. It should be noted, too, that slightly less brush pressure is needed on slotted commutators than on those having flush mica.

Filling Commutator Slots.

Mention was made previously of the fact that dust, dirt, etc., may accumulate in the slots of undercut commutators and cause trouble. This source of trouble is encountered chiefly where machines are operated in wet or dusty surroundings and where the commutator cannot be kept entirely free from oil and grease.

Under conditions such as these it is advisable to coat the slots with a good grade of shellac, care being taken to see that the shellac and brush are free from dirt and moisture. The slots may be filled with a suitable insulating varnish or cement, if desired. This varnish or cement should dry hard and show no tendency toward becoming gummy when the commutator temperature rises under operating conditions. An abrasive cement should not be used since this will cause excessive wearing down of the brushes. If the cement is harder than the copper of the bars, "high cement" rather than high mica may develop. For these reasons a varnish or cement should not be used to fill the slots unless it is of a type specially prepared for this purpose.

Cleaning V Ring Band.

A band of insulating and binding material is placed around the ends of the V rings as shown in Fig. 4 to protect the mica cones and to prevent the development of short circuits and grounds.

This band should be wiped off sufficiently often to keep it reasonably clean at all times. The painting of this band with a good air drying varnish every few months is recommended. This painting makes cleaning easier, helps to preserve the band, and provides a smooth surface upon which dust and dirt will not readily collect.

Replacing Commutator Bars or Mica.

Considerable care must be used when replacing damaged commutator bars or mica, otherwise the entire commutator may be seriously damaged. The following paragraphs give a brief outline of the most important steps which should be followed in this work.

A few turns of wire should first be wrapped tightly around the commutator to prevent the bars from

separating when the clamping ring is removed later. The armature coil leads should then be detached from the bars which are to be replaced, after which the bolts or ring nut holding the front metal V ring in place should be carefully removed. The V ring and mica cone can then be removed. Care should be taken at this point to avoid injury to the mica cone. The binding wire which had been placed around the commutator should then be removed and the bar to be replaced should be tapped, so as to drive it forward, until the bar can be taken out. It should be noted here that an attempt should not be made to replace more than one bar at a time, in case two or more bars must be replaced. Trouble usually arises if this is done. One bar should first be replaced, then the second, and so on until the work is completed.

The new bar must be of exactly the same size, shape and taper as the old bar. It is very important that these points be carefully checked. A considerable amount of filing is usually necessary in preparing a bar which meets the requirements just noted.

New mica should be inserted after the slot is cleaned, and the new bar then carefully driven into place. The mica should extend at least $1/16$ inch beyond the bars at the rear of the commutator, as shown at F in Fig. 4, in order to prevent the development of short circuits between bars at this point.

The mica cone, the metal V ring, and the V in the ends of the commutator bars should be cleaned, sandpaper being used if necessary. The V in the ends of the bars should be painted with shellac, care being

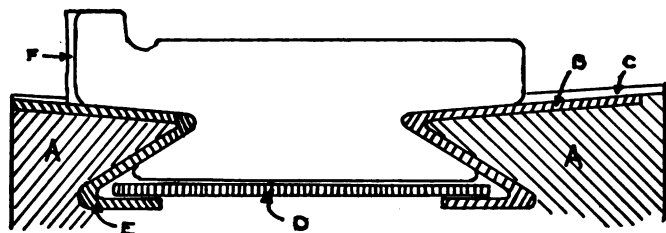


FIG. 4—Section through a commutator. (A) Metal V rings. (B) and (E) Mica V rings or "cones." (C) Band on front V ring. (D) Mica bushing. (F) Mica extending beyond bars at rear end of commutator.

taken here to use only shellac and a brush which are free from moisture and dirt. If the mica cone is damaged, even slightly, during removal or handling, it should be replaced by a new cone which is free from defects.

The mica cone and the metal V ring are then carefully placed in their original positions, after which the bolts or ring nut should be drawn up until fairly tight and the armature leads attached to the bars.

The commutator should then be heated, either in an oven or by means of a gas ring, to a temperature of about 105 or 110 deg. C. The bolts or ring nut are then drawn up tight before the commutator is allowed to cool. If necessary, the mica is then undercut as described previously. The final step in the work includes turning in a lathe, polishing the surface, and testing for grounds and short circuits.

When turning an undercut commutator it is impossible to prevent the tool from forming a burr which projects into the slot on the trailing edge of each commutator bar. This burr should be removed

from each bar by the use of a commutator slotting file or a scraping tool of proper shape.

Soldering Leads to Bars.

Certain commutator troubles frequently arise from defects resulting from improper soldering of armature coil leads to the commutator bars. Brief reference to this work may, therefore, well be included here.

Satisfactory results cannot be expected unless the work is done with a hot iron which is kept well tinned. An iron of fairly good size is necessary, one of two or three pounds weight being satisfactory for ordinary work. An iron can be well tinned by filing and cleaning the surfaces, heating, dipping in a strong solution of zinc chloride, and then rubbing solder on the hot iron.

The "half and half" solder, consisting of half lead and half tin, is satisfactory in case the machine will not be subjected to unusually high temperature and the commutator surface speed is not exceptionally high. If the machine will be operated under the conditions just mentioned it is desirable to use a solder of pure tin, even though this solder is harder to work and is more expensive.

A suitable flux should be used to make the solder flow more easily and take hold of the metal. Soldering compounds, or fluxes, of various kinds are available, some of which are not suitable for the work under consideration. It is very important that the flux used does not contain acid. Acid will injure the insulation of the coils and cause short circuits and grounds.

During the work of soldering care must be taken to prevent the solder from flowing back of the neck or riser of the commutator bars. It is well, for this reason, to raise the rear end of the armature so that excess solder will tend to flow to the front end of the commutator neck or riser. It is also recommended that the armature be turned so that the leads will be soldered at the side of the commutator rather than at the top of the commutator. It is rather difficult to prevent the solder from flowing behind the bars when the work is done at the top of the commutator.

All parts to be soldered must, of course, be well cleaned and tinned. If the commutator is undercut care must be taken to remove all solder which may have entered the slots between bars.

Conclusion.

The proper maintenance of a commutator is so important that the points which should receive the most attention may well be summarized here. These may be briefly stated as follows: Keep the commutator free from oil, grease, and moisture. Eliminate sparking in so far as is possible. Keep the face of the commutator clean and smooth, attempting to maintain a well polished surface of a clean dark brown color. Keep the commutator tight and free from flat spots, high or low bars, and eccentricity. Keep the slots of undercut commutators clean. Undercut the mica of these commutators when the slot depth becomes less than $1/64$ inch. Keep the front V ring clean; paint it with a good air drying varnish, after cleaning, every few months.

If careful attention is given to these items frequent repair of commutators should not be necessary and their useful life should be greatly increased.

Steel Institute Meeting Well Attended

Judge Gary Urges Friendly Co-operation in Industry—Possibility
of Holding an International Conference of Iron and
Steel Manufacturers Broached

MORE than 1,500 executives of the iron and steel industries met at the Hotel Commodore, New York City, October 22, for the thirtieth general meeting of the American Iron and Steel Institute. The sessions, of which this month's was one of the largest in the history of the organization, are held semi-annually.

Judge Elbert H. Gary, president of the Institute, opened the convention with an address in which he broached the possibility of holding an international conference of iron and steel manufacturers in which problems confronting the industry could be freely discussed. Six technical papers were read, three each at the morning and afternoon sessions. The delegates were guests of the Institute at luncheon and the convention closed with a banquet in the ball room in the evening.

Of the possibility of the international conference, Judge Gary had the following to say: "We have heard recently of considerable discussion relating to anticipated competition between the iron and steel manufacturers of the United States and their foreign competitors; but it is believed that should it become necessary, an international conference would be held between all these interests, and a full open discussion indulged in, after which a fair understanding could be reached.

"Of course, no agreement between the different interests relating to prices could legally be entered into without the sanction of our law administrators. But if the necessity arose, it is thought the approval of the public authorities of this country, if they were fully informed and permitted to express opinions on the subject, might be obtained.

"Conferences, open discussions and reasonable bases for maintaining peace and prosperity in business matters have become popular and desirable all over the world. It is not too optimistic to assert that a platform of peace and prosperity could and will be adopted, and if so would be adhered to. Briand and Straseman (the speaker had previously dwelt upon the recent pledges given by these statesmen that their nations were to follow the paths of peace) built better than they knew. Let us do our part, up to the limits of our right and opportunity."

Judge Gary urged that friendly co-operation be practiced by those in the industry. He touched also upon business conditions in the country in general and those in the industry in particular.

"There appear to be no clouds on the business horizon which indicate the demand for steel products in the aggregate will be substantially reduced in the near future, although necessarily in a matter of this kind the perspective must be limited as to period time.

"The crop reports as we have them indicate the production this year will be nearly as large as in 1925, which was a bountiful year. Money is plentiful. Collections are satisfactory, indicating the soundness of the credit situation. There is sufficient labor to meet all demands and, we think, should be and is entirely satisfied with rates of pay and conditions of employment.

"One thing we know positively, namely, that the administration at Washington is reasonable and fair towards

all business and all interests; and we have reason to believe that the majority in Congress will support the policies and good work the President has inaugurated from time to time and performed to the satisfaction of the people.

"So far as the question of import tariffs is concerned, we believe no legislation will be attempted, and certainly none passed, which will be really harmful to the business of the country. While there will be continued competition in the steel industry by foreign producers, we think from the statements they make there is no reason to feel they will seriously interfere with production of the United States. We have faith in the future.

"Corrosion of Structural Steel," the first paper to be heard by the delegates, was read by F. N. Speller, metallurgical engineer of the National Tube Company of Pittsburgh. The question of possible destruction of the steel framework of modern buildings by corrosion had been revived during the past year, Mr. Speller stated, and it would be well, he affirmed, that the industry give some attention to the subject. After touching upon the causes of corrosion, and giving examples of corrosion in steel frames, Mr. Speller made the following suggestion:

"Many old structures are available for examination each year in this city. Some permanent means should be established for the inspection and testing of these structures. It is suggested that a representative commission of engineers be appointed to examine and report on the condition of the steel work in old buildings, especially when they are being demolished to make way for new structures. The recommendations of such a commission should afford valuable suggestions for improvements in the design and maintenance of steel structures and should tend to set at rest any apprehension as to their safety."

Welding as one of the greatest labor saving devices employed in modern industry was the subject treated by Comfort A. Adams, Director of the American Bureau of Welding in New York City in his paper, "Welding of Iron and Steel." The speaker described and discussed the various methods of welding and spoke at length on its applications.

A general discussion of plate mills and the problems confronting that section of the industry was presented by F. M. Gillies, superintendent of the plate mills of the Inland Steel Company, of Indiana Harbor, Indiana.

"The tendency is plainly to meet the exact demands of the customer. The production of plate will probably not become less competitive and by this reasoning the sooner plate manufacturers accept this to be the situation, the sooner will improvements be made and economies result," stated Mr. Gillies. "This will enable the operators to breathe more freely, knowing that they can face the trade without excuse and with an acceptable product."

"The Use of High Manganese Basic Pig Iron and Manganiferous Ores in Open-Hearth Steel Practice" was the subject of a paper by A. W. Smith, works superintendent of the Youngstown Sheet and Tube Company, Youngstown, Ohio, and A. N. Diehl, vice president of the Carnegie Steel Company, read a paper on "The Action of Sulphur in Basic Open-Hearth Steel Practice."

The banquet with which the conference closed was presided over by Judge Gary. James A. Farrel, president of the United States Steel, was chairman of the committee in charge of the convention. Those who served with him were E. A. Clarke, secretary of the Institute; Eugene G. Grace, president of the Bethlehem Steel Corporation; Charles M. Schwab, John A. Topping and James A. Burden, Burden Iron Company, Troy, N. Y.

Iron and Steel in Australia

Furnaces, rolling mills, and engines made at Pittsburgh are in continuous operation at Newcastle, New South Wales, Australia, by the Broken Hill Proprietary Company, therefore the figures of production of this company during its last fiscal year should interest Pittsburghers.

Product	Fiscal Year		
	1923-24	1924-25	1925-26
Pig iron, tons.....	306,258	358,861	333,025
Steel rails, tons.....	75,824	76,910	65,268
Other steel, tons.....	158,784	192,536	201,556
Coke, tons.....	305,084	338,440	326,127
Tar, gallons.....	3,574,341	3,693,532	3,418,577
Ammonium sulphate, tons...	4,545	4,821	4,883
Benzol spirit, gallons.....	826,876	1,115,885	1,153,614

The iron ore reduced amounted to 586,000 tons, which was mined in the State of South Australia and sent by ship to Newcastle. A local quarry supplied 127,076 tons of limestone, and the coal comes from the company's own mines near Newcastle.

Severe competition was felt with foreign iron and steel. Labor troubles and adverse industrial legislation are a heavy handicap to more successful operation.

Red Cross Roll Call

Volunteer Roll Call groups headed by representative leaders in the metallurgical field have enlisted to secure the maximum response throughout these lines in New York City to the annual Red Cross Roll Call, opening November 11, Armistice Day, for funds to maintain the organization's relief work and public health program.

John A. Topping, president of the Republic Iron & Steel Company, heads as chairman a special Iron and Steel group; Mr. Chas. Hayden, of Hayden Stone & Company, is chairman of a Mining, Smelting, Pig Iron and Brass group, and Mr. Samuel B. Donnelly,

of the Allied Building Metals Association, heads a Bronze and Allied Metals Industry group.

These groups are among the first 100 groups formed in accordance with the campaign plan of committee organization of the city into various industrial, banking, mercantile and professional groups which will carry the Roll Call appeal into every branch of industry. It is anticipated that by the opening of the Roll Call approximately 200 such groups will be functioning throughout the city, representing a total of 4,500 volunteer chairmen, committeemen and captains.

Plans for comprehensive activity throughout the groups are already in operation under the leadership of the chairmen, and Mr. Topping, Mr. Hayden and Mr. Donnelly have set as their goal a 100 per cent enrollment with a Red Cross button on every person in the metallurgical field.

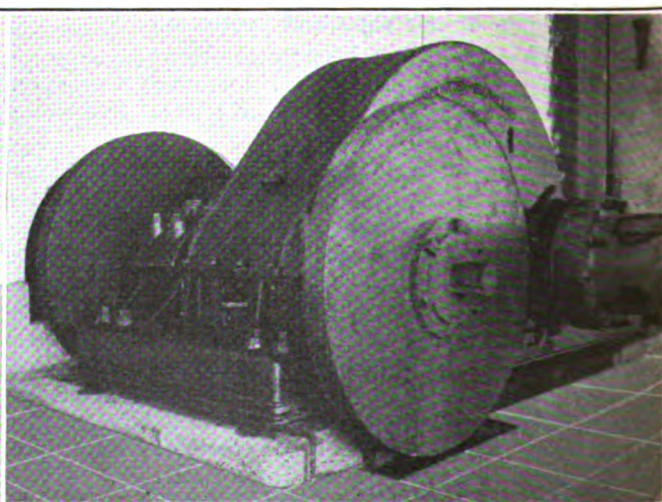
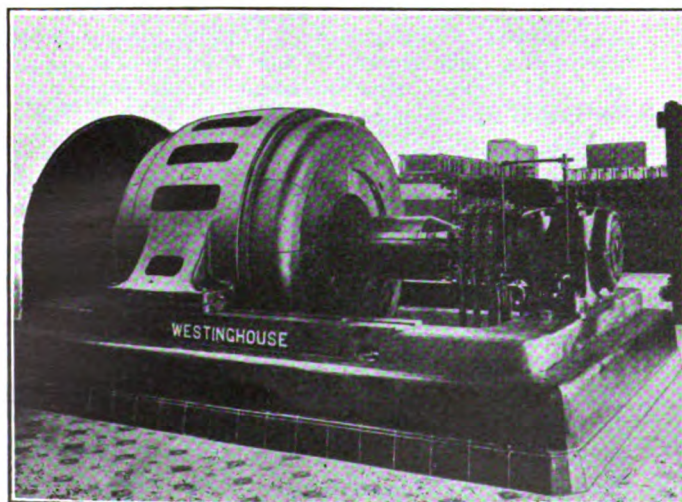
Aid for ex-service men and their dependents constitutes a major part of the Red Cross program in New York. More than 4,000 wounded veterans, men still in service and members of their families were aided during the year, according to the last annual report of the chapter. Legal assistance, money loans and medical advice are included in this work.

Other outstanding metropolitan activities are the disaster relief and the public health program, under which more than 616,000 surgical dressings were supplied during the year to hospitals of the city, and which also covers nursing service, first aid and work in home hygiene and care of the sick.

Huge Motor and Reduction Gear in Spanish Steel Mill

Thirty-five cars were required to ship from the East Pittsburgh Works of the Westinghouse Electric & Mfg. Company, the equipment for the Spanish Steel Mill located at Sagunto, Spain. The illustrations of the motor and reduction gear give some idea of the size of the rest of the shipment, which was made in 1924, but the plant has only recently been completed.

This 3000-hp., 5,250-volt, 735-rpm. induction motor is installed in the 111-inch plate mill of this Spanish mill, driving through the 14 to 120 reduction gear. The pinion is cut integral with the shaft, two eight-ton flywheels of the laminated steel are assembled, one on each end of the pinion shaft. The plate mill was built by Mackintosh-Hemphill Company, Pittsburgh.



Motor and reduction gear for Spanish steel mill at Sagunto, Spain.

A. I. M. & M. E. Meets at Pittsburgh

Excellent Technical Papers Presented on Wide Variety of Subjects—Day Devoted to Inspection Trip up Monongahela River to See Coking Plant and Pipe Making

THE American Institute of Mining and Metallurgical Engineers held its one hundred and thirty-fourth meeting at Pittsburgh during the second week of October. The technical sessions consisted of the fourth meeting of the Open-Hearth Committee of the Institute, a conference on combustibility and testing of coke, and papers and discussion on iron and steel, coal mining, ventilation of mines, and natural and by-product gas. A whole day was devoted by 350 persons to a boat trip up the Monongahela River as far as Clairton to see the coking plant there and the making of pipe at McKeesport.

OPEN-HEARTH CONFERENCE

The first meeting was held in the William Penn Hotel on the fifth, with about 70 in attendance, and the second meeting at the Bureau of Mines Experiment Station on the sixth. On the seventh the open-hearth shop of the Pittsburgh Steel Company at Monessen was visited.

The papers presented are as follows: (1) "The Basic Open-Hearth," by R. L. Cain; (2) "The Open-hearth Charge," by P. H. Schaeffer, formerly open-hearth superintendent of the United Alloy Steel Corporation at Canton, Ohio; (3) "Mineralogical Composition of Open-Hearth Bottoms and Its Relation to Slag Attack," by W. J. McCaughey, Columbus, Ohio; (4) "The Effect of Refractories on Steel Making;" (5) "The Absorption of Sulphur During Melting in the Open-Hearth Furnace," by C. H. Herty; and (6) "The Desulphurizing Action of Manganese in Iron," by C. H. Herty and J. M. Gaines. There was some discussion of these papers, which will probably be given later in abstract in this journal.

Committee Work.

The chairman, C. B. Collingwood, of Bridgeport, Conn., of the sub-committee on open-hearth design indicated that not much progress had been made in obtaining plans of existing open hearths. When these are available it is hoped to design a standard furnace which will burn gas, oil, or tar.

As a result of the request for suggestions for papers for the next meeting, these may cover the forging of steel, the relation of hot metal to quality steel, the pouring of steel, and furnace bottoms and alloy steels.

COKE CONFERENCE

This conference, without prepared papers, was held at the Bureau of Mines Experiment Station on October 5. A. C. Fieldner, chief chemist of the Bureau, presided over about 50 in the morning when combustibility was discussed and over 25 in the afternoon when testing was the topic. These included representatives of the Coal and Coke Committee of the A. I. M. & M. E., American Society for Testing Materials, U. S. Bureau of Mines, Eastern States Blast Furnace and Coke Oven Association, Carbonization Committee of American Gas Association, Southern Ohio Pig Iron Producers' Association, and Gas and Fuels Divisions of the American Chemical Society.

Combustibility of Coke.

The discussion was opened by R. H. Sweetser of the American Rolling Mill Company, who held that the combustibility of coke can be changed by a change in oven practice. Blast-furnace coke should be large and hard. Combustibility and reactivity of coke were different.

H. J. Rose of The Koppers Company agreed that by correct coking practice the combustibility can be changed. The size of the coke was important, also the closeness of screening.

G. W. Hughes of the Pittsburgh Steel Company, did not favor very hard coke, nor the mixing of 48, 72 and 96-hour coke, nor too much fine coke—not finer than 1-inch mesh.

P. Nicholls of the U. S. Bureau of Mines agreed that combustibility and reactivity were different, and J. D. Davis of this Bureau told of what studies were being made on the reactivity of coke. O. P. Hood, also of this Bureau, thought that the difficulty is not in getting the coke to burn but in getting the air to the coke. It is a mechanical, not a chemical problem, and the question is, what is the opportunity for combustion? A. C. Fieldner suggested that the value of low-temperature coke be further investigated.

W. B. Havens, for the Eastern States Blast Furnace and Coke Oven Association, believes that the nature of the coal from which coke is made is more important than the method of coking, and the size of the coke is the greatest controlling factor. After the session on testing of coke, Mr. Sweetser proposed a definition of combustibility of a blast-furnace coke, but final action was postponed after a contrary opinion by Mr. Havens.

Testing Coke.

The discussion was opened by A. C. Fieldner, who said that apparently the furnace men did not seem to know what kind of coke they wanted, and it was desirable to come to some understanding so that the American Society for Testing Materials does not devise and standardize tests which have no relation or a false relation to the real needs of the coking industry.

R. H. Sweetser considered that no physical test is satisfactory and the coke needed for furnaces of different heights and for different kinds of iron vary.

W. A. Selvig of the Bureau of Mines, and representing the A. S. T. M., said that the shatter and porosity tests were fixed, and the standards for tumbling and weight per cubic foot were being considered. W. B. Havens and P. Nicholls considered the tumbler test better than the shatter test; and D. A. Russell of the Youngstown Sheet & Tube Company, thought the sizing test more important than the tumbler test.

IRON AND STEEL

First Session.

The first session on iron and steel was held in Carnegie Institute on Wednesday the sixth at 2.00 P. M., with S. L. Goodale as chairman. There were 50 pres-

ent. (All of the papers presented are available in pamphlet form by writing to the A. I. M. & M. E. at New York.)

1—The trend of development in the wrought-iron industry was reviewed by James Aston, professor of mining and metallurgy in Carnegie Institute of Technology, and formerly with the A. M. Beyers Company of Pittsburgh, well-known makers of wrought-iron pipe. Mr. Aston read significant parts of his paper, and particularly discussed the mechanical puddling of iron has not proved to be a general success. He described his own patented process in which molten iron (2800 deg. F.) is poured into a bath of slag (2100 deg. F.) whereby solidification and evolution of gas take place and the slag is disseminated through the iron almost instantaneously. Then the ingot is squeezed in a 500-ton press. The wrought product is satisfactory for all purposes.

In the ensuing discussion, F. N. Speller of the National Tube Company suggested that in stating the outstanding needs—lower costs and greater tonnage—of the wrought-iron industry, Mr. Aston might have given some data thereon. Mr. Speller thought that wrought iron has been living on its reputation and proof has to be shown of its superiority over steel. He also asked what grade of metal had been produced.

R. H. Sweetser of the American Rolling Mill Company asked what was the composition of the slag desired for mixing with the iron. Mr. Aston said that this slag carried about 50 per cent FeO and 12 to 20 per cent SiO₂, some P₂O₅, MnO, and Al₂O₃.

S. L. Goodale discussed the two operations in making wrought iron by the Aston process. He can not see the value of the slag in the iron as the tendency of the industry is in the elimination of slag.

G. E. Zeigler asked whether Mr. Aston had ever observed wrought-iron microscopically, because his observations had shown the product to consist of large and small crystals. Mr. Aston replied that his practice had been limited to the metallurgy of wrought iron and every means of test had been employed over a period of 10 years. The material produced had no different characteristics.

2—A description of the largest steam-hydraulic forging press, by W. J. Priestly of the Electro-metallurgical Sales Corporation, New York, was given by R. S. Poister of this firm.

John Arthur, of the Ordnance Department, stated that the press was a monument to the builders, the Mesta Machine Company of Pittsburgh.

3—Tests on galvanized sheets were next reviewed by H. A. Stacy of the Bureau of Yards and Docks of the Navy Department.

E. S. Taylerson of the American Sheet & Tin Plate Company agreed that bend tests were not a good criterion of adherence of coating because of the method of making the tests.

G. A. Reinhardt of the Youngstown Sheet & Tube Company thought that as so few samples were tested the work should be continued. Mr. Stacy said that this work occupied three years, yet they realized that more should be done but they wished to publish the results at this time.

R. O. Griffith of the American Rolling Mill Company discussed the Erickson machine as a method

for testing sheets and the effect of large and small spangles in testing. Mr. Stacy said that the machine gave erratic results and the spangles were not considered in testing.

4 and 5—A progress report on the effect of the open-hearth process on refractories, by F. W. Schroeder and B. M. Larsen of the U. S. Bureau of Mines; and optical temperature measurements in the open-hearth furnace, by B. M. Larsen of the U. S. Bureau of Mines and J. W. Campbell, research fellow of Carnegie Institute of Technology, were briefly reviewed by Mr. Larsen. As these papers were discussed at the Chicago meeting of the Open-Hearth Committee, there was no discussion.

Second Session.

The second session was held in Carnegie Institute on Friday, the eighth, at 10 A. M., with James Aston, as chairman.

1—"The Specific Efficiency of the Blast Furnace" was reviewed by Richard Franchot of the Ferro-Chemicals, Inc. The main points brought out by the discussion by G. P. Hansen, S. P. Kinney, T. T. Read, and C. E. Sims are: (a) The blast furnace has to perform several functions and its actual efficiency should be compared with the theoretical efficiency possible in their combination; (b) the actual existence of the surplus of heat in the stack, as indicated by Mr. Franchot's calculations, is at least open to question; (c) the drawing off of part of the products of combustion somewhere about the bosh would give rise to practical problems for which no solution has yet been indicated.

2—A paper on the use of iron and steel scrap in blast-furnace burdens, by W. C. McKee, general superintendent of the Federal Furnace Plant, Chicago By-Products Coke Corporation, was presented in abstract by T. T. Read in the absence of the author.

The main topic of the discussion was whether pig iron made from a burden with scrap in it was of as high quality as when made from ore only. The blast-furnace men present considered that unless copper, chromium, nickel, or some other disturbing element was introduced into the furnace with the scrap, the resultant pig iron must be of as high quality as when reduced from ore. The foundrymen held that other differences were discernible. Whether the scrap produces a cleaning effect on the furnace and could be used to promote its free working was another point raised. On the other hand, others held that if the furnace was burdened to capacity with ore it did not have any heat to spare for the melting of scrap.

3—The composition of iron blast-furnace slag, by Richard S. McCaffrey, professor of metallurgy, Joseph F. Oesterle, assistant professor, and Leo Schapiro, fellow, University of Wisconsin, Madison, Wis., was the last paper, and was summarized by the senior author.

In discussion, C. E. Sims, electrometallurgist of the Bureau of Mines, pointed out that in addition to the four components of the slag shown in tetrahedral models exhibited, there are various others present, such as the alkalies and titanium, which have a marked effect on the mineralogical composition of the slag and which have to be taken into account in any final analysis. Blast-furnace men indicated that they could not easily apply the data presented to their regular operations.

Book Review

(The books reviewed in this section can be secured from The Blast Furnace and Steel Plant, Box 65, Pittsburgh, Pa.)

Handbook of Non-Ferrous Metallurgy. Edited by Donald M. Liddell, and written by 36 specialists. Two volumes (not sold separately)—No. 1 of 692 pp. and No. 2 of 748 pp. Published 1926. Price, \$12.

Many Pittsburgh metallurgists will find great value in this new handbook on which subject the profession has lacked an up-to-date reference for a long time. Iron and steel are not the only metals produced in the Pittsburgh district. Although aluminum is not actually reduced here it is the greatest center at New Kensington and Arnold for rolling and fabricating that metal, and gives employment to several thousand persons. Copper was once reduced at Natrona from ores and pyrite in the manufacture of sulphuric acid, but it is produced as secondary metal and the working of the metal in Pittsburgh is extensive. Lead is produced at Carnegie and worked at a number of plants. Tin is used by thousands of tons in the tin-plating mills, particularly at McKeesport. On Neville Island is a de-tinning plant, but this does not make tin metal, only tin salts; and a great deal of tin is recovered from dross from the tin-plating mills and sold as solder and oxide. Zinc is reduced at two of the largest smelters in the world at Donora and Langeloth, and is consumed in zinc-coating plants at Donora, Pa., Weirton, W. Va., and other centers. Vanadium is reduced from Peruvian ore and converted into ferro-vanadium at Bridgeville. In addition to these operations, a large business is done in alloying metals and working them, and in recovering secondary metals of high quality from scrap. The metallurgy of the virgin metals mentioned above and others are fully treated in this work.

Volume I consists of 18 chapters, many of which are on processes and materials common to all metallurgical operations, such as metallography, crushing and grinding, sampling, screening, classification, concentration, fuels, pyrometry, roasting and sintering, refractories, separation of solids and liquids from gases, briquetting, power plant and electric furnaces.

Volume II, of 25 chapters, briefly deals with minerals and the occurrence of the non-ferrous metals and completely covers their extraction from ores. There is no need to mention these metals, but they include all from the alkali metals to zirconium—to list them alphabetically. To quote the Editor-in-Chief in the Preface:

The scheme of treatment in the various chapters is not uniform—it intentionally is not so. In general, the attempt is made to treat at greatest length those metals of prime commercial importance, but this plan is departed from if it is felt that existing literature on a certain metal is not readily accessible to the ordinary metallurgical engineer.

As a much-needed work we consider that "Handbook of Non-Ferrous Metals" should be on every metallurgist's bookshelf.

—M. W. von Bernewitz.

* * *

Stainless Iron and Steel. By J. H. G. Monypenny. 304 pages and 109 illustrations. Published 1926. Price, \$6.

"Stainless steel" is almost a household term and its products and uses are expanding. The author of this work, a British metallurgist with a large firm at Sheffield, states that the popular notion as to the single character of stainless persists, although incorrect, in spite of a wide range of diverse materials included in the term stainless steel which permits widely varying properties to be obtained from different types of this material.

Stainless steel is a patented steel which contains about 13 per cent of chromium and 0.03 per cent carbon. It is non-corrodible, non-tarnishable, not oxidized when heated to the usual tempering temperatures, and not attacked by several acids, including nitric, or by the corrosive gases from the exhaust of gas engines. It is, therefore, coming into use for apparatus and machine parts subject to corrosive influences, also for cutlery and hardware. It is the chromium that greatly increases the resistance of iron-carbon alloys to atmospheric and water corrosion and to the action of food acids, also to that of nitric acid. The less carbon the iron-carbon alloy contains the more readily the stainless properties are imparted to the steel. The stainless steels which contain from 0.25 to 0.40 per cent carbon and 13 per cent chromium require heat treatment and polishing to bring out their best resistant qualities. Hydrochloric, sulphuric, and sulphurous acids attack stainless steel or iron readily, but nitric acid of all strengths has virtually no action on such metal and is, therefore, a good criterion for distinguishing from ordinary iron and steel.

In the 16-page chapter on the history of stainless steel we are surprised to find no reference to the work of Elwood Haynes, an American inventor who died recently. Harry Brearley of Sheffield is credited with the discovery in 1913 of the resistance to corrosion of high-chromium steel. His United States patent (No. 1197256) was filed on March 29, 1915, and granted on September 5, 1916. The specifications gave a limit of 0.7 per cent carbon and 9 to 16 per cent chromium. Haynes carried on experiments at about the same time as Brearley, but independently, and reached similar conclusions as Brearley. Haynes' patent (No. 1299404) was filed on March 12, 1915, and granted on April 1, 1919. The specifications gave 0.1 to 1 per cent carbon and 8 to 60 per cent chromium. Brearley's Canadian patent (No. 164622) was filed on April 21, 1915, and granted on August 31, 1915.

In the application of stainless steel, the study of the microstructure is of especial value as the observations indicate not only the cause of varying mechanical properties, but also the reasons why the materials offer varying resistance to corrosion. Therefore, the author devotes considerable space to this study, and shows many photomicrographs of treated stainless steels.

The chapters on the manufacture, working, and treatment of stainless steels; their mechanical and physical properties; the influence of varying treatment and composition on their resistance to corrosion; and their resistance to various types of corroding media are well presented and of practical import.

Forty pages is devoted to the properties and working of special stainless steels, such as chromium-silicon steels, chromium-nickel steels, chromium-nickel-silicon steels, and chromium-molybdenum steels.

The last chapter gives details of the many applications of stainless steels—in steam locomotives (15

parts); hydraulic pump plungers, valves, and seatings; blades for steam turbines; parts of lathes; and in nitric acid plants.

—M. W. von Bernewitz.

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The Story of Steel. By J. Bernard Walker. 208 pages, illustrated. Published 1926. Price, \$4.

"The Story of Steel" is told in untechnical but accurate language so that anyone may grasp what is meant. It begins with the mining of the ore and pictures the activities of the greatest iron mine in the world. The steady movement of ore train and steamer are graphically described, until the ore mill is reached. Then the real story of steel begins. One almost feels the great blast furnaces as each detail of their operation is described and the crude ore passes out into huge steel ingots. The manufacture of coke, so necessary to steel, is discussed. And then you are taken into the rolling mills, where rails, wire and nails, and the massive shapes for bridges and buildings are rolled out in never-ending streams. Steel pipe and tubes, plates, sheets, tin plate—the processes of all are accurately described.

There are human elements, too, in the story of steel; for the vast army of workers must be protected against accident, must live and work and play. There are interesting chapters on the campaign for safety and on welfare work.

Finally the important subjects of financing and marketing are adequately covered in special chapters, two of which have been contributed by Edmund Brown, Jr., Member Consulting Board, Brookmire Service. Graphic photographs and drawings illustrate and clarify the text.

The author has been in close touch with the steel industry for many years. He has made extended tours through the great steel properties of the United States, and writes with a sure touch and thorough knowledge.

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Geschichte des Eisens (The History of Iron). By Dr. Otto Johannsen, published by Stahleisen, Dusseldorf. 1925.

The author begins this excellent history of iron with a short description of methods of iron production of the native races of Australia, America, Africa and Asia. The history then continues with the early knowledge of iron by the Egyptians, Semites, Greeks and Romans.

From this he goes over to the middle ages taking up in order the early iron history of the Spaniards, Gauls, Britains and Germans. The latter half of the iron history of the middle ages is covered in considerable detail. It is related that mining started in the year 1198 at Liege and in 1100 by the Augustine monks of Klosterrath. The beginning of hard coal mining dates back to 1302 in the Duchy of Mark and to 1400 in the Saar. In the year 1234 mining started in Newcastle-on-Tyne. The coal from Newcastle was taken by ship to London and even to Hamburg, and the smoke nuisance was already a fact in London in 1273.

In the beginning, iron was produced with charcoal but in the 16th century the conservation of forests severely curtailed the production of iron. The construction of new plants was forbidden and each plant was only permitted to blow and forge at certain times. The production of charcoal is taken up in detail as is also the mining and preparation of the ores. The

catalan forge, with various methods of producing blast, is described. This is followed by a description of the Stuckofen or forerunner of the blast furnace.

The direct production of steel from ore and the various types of forging hammers are mentioned. The production of plates and products made from plates, such as steel helmets and armor is described. This is followed by the manufacture and products of wire, as the coat of mail, etc. The forging of swords, nails and miscellaneous forgings is quite complete. The section ends with the description of the forging of cannons.

A chapter is devoted to the age of the charcoal blast furnace, the origin of the blast furnace, its construction and operation. The casting and molding of grey iron with illustrations of a number of stove plates follows. The finery is also described. Reference is made to the developments which took place in Germany, Lorraine, France, Italy, Scandinavia, Russia, America and England.

The Coal Age is taken up in Chapter IV. Beginning with the invention of the steam engine and describing in great detail the trials of Watt in the development of this invention, the author continues with the improvement of blowing engines, and the advent of cast steel.

Dud Dudley is credited with the idea of using coke in the blast furnace, but Abraham Darby, was the first to successfully use it. Due to his early death, his son Abraham Darby II reaped the harvest of his father's efforts. Experiments in the use of coal for smelting continued, and in 1772 John Wilkinson was successful in smelting iron ore with coal in the blast furnace. He also installed the first steam blowing engine in 1776. The development of the cast iron foundry in England in the eighteenth century and the beginning of the use of iron rails in 1767 is briefly described.

The invention of the reverberatory furnace by Henry Cort in 1784 and his invention of the rolling mill the year before were of prime importance to the English iron and steel industry. In spite of this Cort died a poor man. The further development of the English Coal technique in the nineteenth century up until the invention of steel is described. It takes up the work of Fulton and Stephenson in the development and use of the steam engine.

The very interesting fact of the last charcoal blast furnace being blown out in 1829 is mentioned. The early coke oven of Lord Dundonald for the recovery of tar, the air blast preheater of Calder, the Dowlus blast furnace and the charging devices of the year 1840 are described in detail. The development of the steam hammer and the rolling mill is described. The author continues with the introduction of the English science and its development in France, Germany and Belgium.

The age of steel starts with the Bessemer process and continues with the beginning of the by-product coke ovens, the improvement in materials handling and pig iron production, the hot blast, the improvements in blast furnace construction, the pig iron mixer, the Siemens-Martin process, the gas producer and the tilting open hearth. The production of alloy steels is briefly taken up.

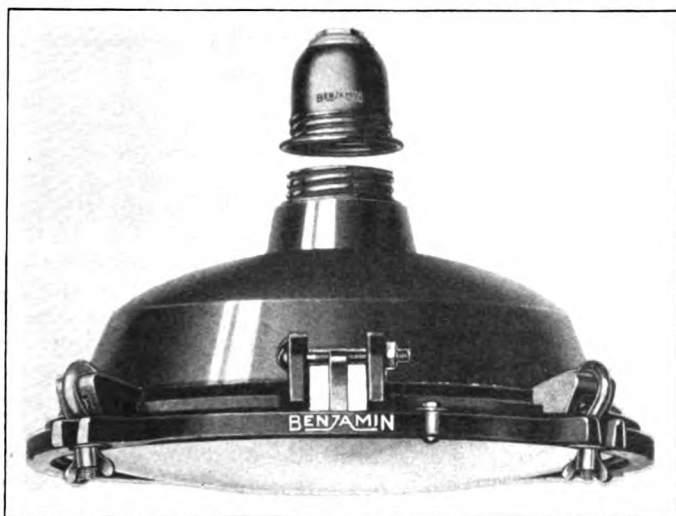
This very excellent work closes with a description of the steel industry in England, America, Asia, Austria-Hungary, Russia, France, Belgium and Germany after the invention of steel.

NEW EQUIPMENT SECTION

Benjamin Type R. R. Reflector.

The Benjamin Electric Mfg. Company, Chicago, developed the Type RR Reflector, for use where rugged, strong and sturdy equipment is required. It is unusually well made, reliable in service and economical in maintenance.

Smoke and grime of blazing furnaces soon deposit film of dirt on reflectors, obscuring from the workers the greatest means of protection from accidents they



Benjamin Type R. R. Reflector.

have. Frequent cleaning of lighting units becomes a necessity which is facilitated through screw-threaded equipment.

The thread on hood and reflector permits easy removal of reflectors for cleaning, and interchangeability among the various types and sizes of reflectors. The rolled screw thread of large diameter is made from heavy copper to resist hard usage, and to prevent "freezing" or corroding of neck of reflector to the hood.

Type RR Reflectors are one-piece, drawn steel, Crystal porcelain enameled to withstand better the corrosive or rusting effects of vapors, fumes, dust, dirt and moisture in exposed interior or exterior installations. All reflectors are finished white inside, Benjamin green outside. Hoods are of two types—Outlet Box Type to fit standard 4 inch outlet boxes, Pendant Type for stem suspension.

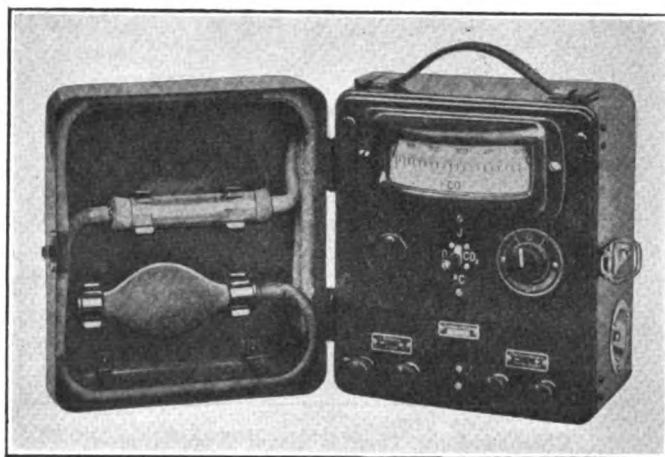
The Type RR Reflectors are made in five styles; Standard RLM Reflector for general lighting in all branches of the steel industry; Fluted Bowl Reflector, suitable for use in foundries, erecting shops, etc., where high mounting conditions make necessary an intensive distribution of light; Bowl Reflector for general illumination where minor shadows are not detrimental and where illumination of vertical surfaces is not required. Serves well also where it is found necessary to light a single machine or bench; Symmetrical Angle Reflector for localized and general lighting where conditions necessitate mounting of

units at the side of the area to be lighted; Shallow Bowl Reflector for the lighting of yards, warehouses and platforms, or where it is desired that one unit light a large area.

Bacharach Portable Electric CO₂ Meter

The Bacharach Industrial Instrument Company, Pittsburgh, has recently placed on the market a portable electric CO₂ meter. The instrument consists of a precision profile indicator at the top, below which is arranged from left to right, the bridge zero adjuster, a tumble switch and the variable resistance for current adjustment. To set the proper bridge current, the tumble switch is thrown into the upper position; this cuts the precision indicator into the circuit as an ammeter and the current is set to the top mark deflection by means of the variable resistor. Three standard dry cells are used as the current source and connected to the two binding posts in the lower left hand corner. When making temperature measurements, the tumble switch is thrown into the downward position, any standard thermocouple can be connected to the lower right hand terminals and the reading made on the millivolt scale. By means of a millivolt-temperature curve the temperature is determined.

For the analysis of flue gas the tumble switch is thrown into the center position. The gas is sampled by means of a hand aspirator which draws the gas through a small calcium chloride and cotton filter,



Bacharach Portable CO₂ Meter.

which when not in use is conveniently held in the cover of the instrument as shown. The instrument is guaranteed to have an accuracy of one-half of one per cent CO₂. The instrument can also be arranged to give continuous indications for short periods (2 to 3 hours).

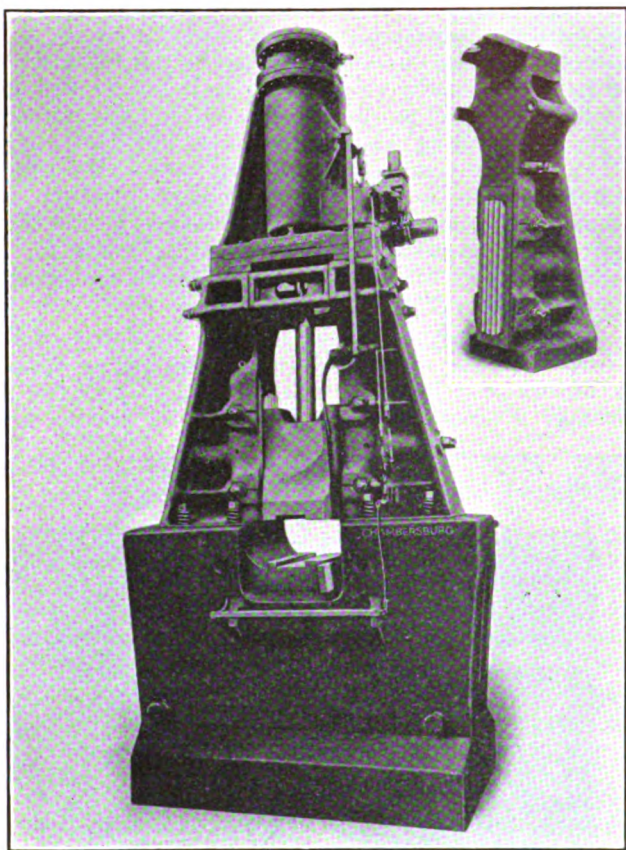
Semi-Refractory Insulating Brick

The Celite Products Company has recently developed a new form of Sil-O-Cel for use at high temperatures known as "Super Brick." This is a specially

prepared and burned product made from the mineral Celite. Super Brick contains a high percentage of Trydymite the physical form of silica that is most stable and uniform at high temperatures. It has a very uniform expansion curve making the brick free from destructive spalling caused by rapid changes of temperature. Super Brick may be exposed to temperatures as high as 2500 deg. F. without harm. The brick is less than one-fifth as conductive of heat as fire brick.

Chambersburg Type B Steam Drop Hammer

The Chambersburg Engineering Company, Chambersburg, Pa., formally introduced at the National Steel and Machine Tool Exhibition at Chicago, September 20 to 24, their 12,000-lb. Type B Steam Drop Hammer, which has been recently put on the market. It embodies several major improvements that will insure the permanency of alignment and decreased operating and maintenance costs.



Chambersburg Type B steam drop hammer.

The anvil has been redesigned so that all sharp corners are eliminated, and large fillets are provided throughout the frame seats. The wearing wedge is installed to take up wear between the frames and the anvil. Frame seats have been raised to a point approximating the dividing line of the dies, so as to materially decrease the tendency of the frames to rock.

The frame to anvil bolts have been provided with keyed heads in the anvil, which are located above the floor line and are, therefore, readily accessible. Cores below the sow block have been eliminated, and the wedges and bolts nearest the sow are inserted in holes bored from the solid metal.

The bearing surfaces on the bottoms of all frames have been increased by extending the frames from left to right. Where single tie bars are standard, they have been dropped below the top of the frame so as to secure greater strength and effectiveness and the frames are tongued to the interlocking tie plate at the top.

The cylinder is of self-draining design, and, in addition, is provided with a removable liner which provides for the most economical renewals.

The safety cylinder cover is furnished as standard equipment.

The interlocking tie plate, has been designed to eliminate any overhanging, thereby, reducing the hazard of breakage. It is dove-tailed in both directions to the frames, fixing them in perfect alignment, and is counterbored to receive an extension from the throat of the cylinder, providing for the maintenance of the cylinder alignment, at the same time the ends of the tie plate lips the base of the cylinder.

The guides have been redesigned to be invertible, as well as interchangeable, and the guide adjusting bolts have been provided with ratchets to lock them in position. The cam mechanism has been redesigned to eliminate all square ends and keys, and the cam and its arm are forged from the solid. The bearing is bronze bushed, as is the bearing on the valve rocker.

Other features that have been retained in the design are the solid forged steel ram, the universally adjustable guides, the two-piece heat treated rod, etc. The new Type B Steam Drop Hammer is designed so as to eliminate studs in favor of through bolts, with the result that the only studs used are some of the packing gland studs, and the cylinder cover studs covering the steam ports.

To Expand Strip Mill Capacity

The Trumbull Steel Company has authorized an improvement program involving expenditure of \$1,500,000, the work to extend into 1927. A strip mill is to be widened from 18 to 36 in., while improvements are being made to the cold strip department.

The company shipped 120,756 tons of finished steel the third quarter, comparing with 109,593 tons the second quarter and 119,632 the first quarter. Its third quarter net earnings were \$585,528, bringing net for the first nine months to \$1,661,651. Improvements authorized will expand monthly production capacity to 60,000 tons.

Construct Strip Mill for Brier Hill Plant

At its Tod plant, Youngstown, the United Engineering & Foundry Company, Pittsburgh, recently erected, for shipment to the Brier Hill division of the Youngstown Sheet & Tube Company, a 20 and 44 in. x 72-in four high hot strip mill. The housings, of cast steel, weigh 114,000 lb. each, being 15 ft. 6 in. wide at the feet, and having a total height of 20 ft. 6½ in. The working rolls are chilled cast iron with ground surfaces, 20 in. in diameter. The mill proper stands on two cast steel bed plates, the beds being supported by cast steel cross ties. The mill is operated by a 2000-hp. variable speed reversing motor through a single reduction, double-helical cut tooth gear drive and a stand of double-helical cut tooth pinions, driving the two working rolls and a bottom backing-up roll.

PERSONALS

Mr. Ollie Needham, of the steel mill section, General Engineering Department, Westinghouse Electric & Mfg. Company was recently promoted to engineer in charge of the Steel Mill Engineering according to a recent announcement of Mr. H. W. Cope, Assistant Director of Engineering.



O. NEEDHAM

Mr. Needham was born in Pottsboro, Texas, but received his education in the State of Oklahoma. He was graduated from the Oklahoma Agricultural and Mechanical College with a Bachelor of Science Degree in Electrical Engineering in 1909. He later entered the apprentice course of the Westinghouse Electric & Mfg. Company, which he completed in two years time.

He then entered the Motor Engineering Department for a six month period and then spent about four years in the testing work. Following this he was transferred to the Steel Mill Section of the General Engineering Department, where he has since remained, handling the applications of electricity in steel mills.

Mr. Needham, during these years has been in very close touch with developments in the design and application of steel mill electrical equipment, and has assisted in the installation of several large important steel mill electrifications at Plants of the Bethlehem Steel Company, of the U. S. Steel Corporation, and also many independent steel companies.

Mr. Needham is a member of the Association of Iron and Steel Electrical Engineers and the American Institute of Electrical Engineers and has presented papers before both of these associations on different occasions. In addition to this Mr. Needham has written several articles for technical press.

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Vernon C. Ward has been appointed manager of the new junior beam department, Jones & Laughlin Steel Corporation, Pittsburgh, and will take up his new duties after a connection of 23 years with subsidiary companies of the United States Steel Corporation. For the past 17 years he has been contracting engineer, Chicago district office, American Bridge Company.

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J. J. Gilmore has been appointed manager of sales of the Birmingham district of the American Steel & Wire Company. The Birmingham office, which has been maintained for some time to sell the products manufactured in the Birmingham district, has enlarged its scope and will sell all the products manufactured by the company.

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D. R. Mathias, general superintendent of the Joliet works of the Illinois Steel Company, has resigned, effective November 1, after 40 years of service with that company. Mr. Mathias entered the employ of

the North Chicago Rolling Mill Company of Chicago in 1886. His first service was in the rail mill as an inspector. In 1889 he was made superintendent of the rail mill, and later he became night superintendent at the South Chicago works. That was closely followed by his promotion to assistant superintendent of the open hearth department, the plate mill and the slabbing mills. His next advancement was to superintendent of the South Chicago works. In November, 1903, he was appointed general superintendent in full charge of the Joliet works.

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M. A. Blessing has been appointed Chicago district manager of sales of the Jones & Laughlin Steel Corporation and Roy H. Atwood has been named as manager of the Chicago warehouse of that company with Louis H. Krieger as his assistant.

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Carl A. Ilgenfritz, formerly general purchasing agent, United Alloy Steel Corporation, Canton, Ohio, has been appointed director of purchases, Central Alloy Steel Corporation of Canton and Massillon. He was formerly purchasing agent at Youngstown for the Brier Hill Steel Company, and was subsequently assistant purchasing agent for the Youngstown Sheet & Tube Company.

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Clyde N. Arnold has resigned as assistant metallurgist, roll and machine works, American Sheet & Tin Plate Company, Canton, Ohio, to become chief metallurgist of the Lewis Foundry & Machine Company, Groveton, Pa.

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In the recent reorganization of the General Engineering Department of the Westinghouse Electric & Mfg. Company, Mr. G. E. Stoltz, formerly head of the Steel Mill Section, and well known for his trade activities in that industry, was promoted to Manager of Industrial Engineering.

Mr. Stoltz was born in Gettysburg, Ohio. He received his preparatory school training there, and was graduated from the Ohio State University in 1909. Immediately following his graduation he entered the apprentice course of the Westinghouse Company. After finishing this course he entered the Steel Mill Section of the General Engineering Department, first as an engineer and later as section head. He retained this latter title until his recent promotion.



G. E. STOLTZ

During his activity in the steel mill industry he placed into operation the first a.c. adjustable speed set in this continent. He also assisted in placing into operation the early reversing blooming mill equipments, and co-operated in the design of the recent single unit reversing equipments.

Mr. Stoltz is a member of the American Iron and Steel Institute, the Association of Iron and Steel Engineers, the A. I. E. E. and the Engineering Society of Western Pennsylvania, and has delivered a number of talks and papers before these various organizations.

John R. Stroh, formerly manager of the raw material department, Brier Hill Steel Company, has been appointed western sales agent for the Pittsburgh Metallurgical Company, Niagara Falls, N. Y., manufacturer of ferrosilicon, with offices in the First National Bank Bldg., Youngstown, Ohio.

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Dr. Birger Egberg, formerly metallurgist with the Halcomb Steel Company, Syracuse, N. Y., has joined the laboratory forces of the International Silver Company, Meriden, Conn.

* * *

George H. Grundy has been appointed president of the Poldi Steel Corporation of America, New York. In 1925 he was connected with the Union Drawn Steel Company, Beaver Falls, Pa., formerly having been manager of steel sales for Peter A. Frasse & Company, New York. In 1923 he was general sales manager of the Poldi Steel Corporation, previously having been New York office manager for the Crucible Steel Company of America.

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William Hilditch has resigned as plant engineer of the Otis Steel Company, Cleveland, effective October 15. He started with the company 20 years ago as a machinist in its Lakeside works, successively being shop foreman, master mechanic, general master mechanic and then plant engineer.

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Warren R. Tyson, recently placed in charge as general manager, Tioga Steel & Iron Company and the Philadelphia Roll & Machine Company, of Philadelphia, had been at one time with the Bethlehem Steel Company. He entered the Tioga company 16 years ago and has held many positions in its producing and selling departments.

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T. H. Kane, who recently was made president of the Berger Manufacturing Company, Canton, Ohio, structural steel fabricating subsidiary of the Central Alloy Steel Corporation, Massillon, Ohio, formerly had been vice president and general manager of the Truscon Steel Company, Youngstown, Ohio.

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Owen R. Rice, formerly assistant blast furnace superintendent, Bethlehem Steel Corporation, has resigned to become associated with the Freyn Engineering Company, Chicago, as an assistant in blast furnace and metallurgical work.

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Wm. Hilditch, after twenty years of service, has resigned from his position as plant engineer of the Otis Steel Company, Cleveland, effective October 15. His career began twenty years ago as machinist at the old Lakeside Works of that company, from which position he advanced successively to shop foreman, master mechanic, general master mechanic, plant engineer. During the last few years, he has had personal charge of all maintenance and construction work, the latter of which included the building of the Otis sheet mills, hot and cold strip mills, open hearths, blooming mill, and the rebuilding of their blast furnaces. Mr. Hilditch states that for the present he intends to take a much needed rest—no plans for the future being announced at this time.

TRADE NOTES

Power Specialty Company has opened a branch office to extend their service to present and prospective users of Foster Convection and Radiant Heat Superheaters, Economizers and Water Cooled Furnaces, and the Aero Unit Coal Pulverizer. This office is located in Room 709, Security Building, at 209 Grant Avenue, Milwaukee, Wis.

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Freyn Engineering Company have been engaged by the American Rolling Mill Company as consulting engineers for the design and construction of a 400-ton blast furnace at their Ashland, Ky., plant.

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The Botfield Refractories Company, Philadelphia, Pa., announces the appointment of the following distributors for Adamant Fire Brick: The Westwater Supply Company, 150 North Third Street, Columbus, Ohio. The Klinger-Dills Company, 129-131 North Jefferson Street, Dayton, Ohio. Coan Equipment Company, 236-242 Murray Street, Fort Wayne, Ind. The Cleveland Tool & Supply Company, 1427-1437 West Sixth Street, Cleveland, Ohio.

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Because of a large increase of Westinghouse business in the Ohio district, and the rapid strides of Columbus as a center of this activity, the officers of that company recently established a branch office in that city. Mr. J. K. B. Hare, formerly in charge of syndicate public utility sales for the Pittsburgh district was appointed manager.

* * *

Air Reduction Company, Inc., has acquired all the assets of the Dayton Oxygen & Hydrogen Products Company at Dayton, Ohio, thus adding another plant to the chain of 52 plants and 169 warehouses that guarantees prompt service to Airco customers throughout the United States. The Dayton plant, will furnish a new production and distributing point for the Air Reduction Sales Company to serve high-purity oxygen and other gases used in welding and cutting. The plant went into operation under Air Reduction management October 15.

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The lead in shipbuilding in the Delaware River district for the month of August was taken by the American Car & Foundry Company, according to a report just issued by the United States Department of Commerce, this lead comprising the number of vessels constructed or in process of construction. The American Car & Foundry Company's records was nine wooden ships of 5,500 gross tonnage. The Wilmington shipbuilding plant of the American Car & Foundry was established during the war for the construction of submarine chasers, eight of which were built and delivered, a curious feature of their construction being that they were built in the car shops of the company under cover; mounted on trucks and hauled for half a mile by locomotive to Brandywine Creek where they were launched. Now that the American Car & Foundry Company have gone in for the construction of pleasure cruisers, the lead in shipbuilding held by this company is likely to continue.

The Struthers Furnace Company, in receivership, is unlikely to resume operations until some reorganization plan, now being developed, is consummated. The company is without raw material supplies, including ore, for winter operations.

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Central Iron & Steel Company, Harrisburg, Pa., has removed its New York office from 2 Rector Street to the Evening Post building, 110 Washington Street.

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The American Rolling Mill Company, Middletown, Ohio, has preliminary plans in progress for the construction of addition to its plant at Ashland, Ky., to include the erection of new buildings and the installation of considerable additional equipment. The entire project is reported to cost more than \$2,000,000, with machinery. It is expected to begin work at an early date. J. Clare Miller is general manager at the Ashland works.

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The Mississippi Valley Structural Steel Company, 208 South LaSalle Street, Chicago, Ill., is said to have plans nearing completion for the early construction of a new steel fabricating works at Twenty-fifth and Division Streets, at Melrose Park, near Chicago, reported to cost more than \$500,000, with machinery. The plant will consist of a group of one-story buildings. H. H. Cosley is manager.

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The Pacific Steel Boiler Corporation, 101 Park Avenue, New York, N. Y., has completed plans for the construction of a one-story works on 141st Street, near the Southern Boulevard, to be used for steel plate specialties; it is reported to cost about \$25,000. Beers-Tapman, Inc., 15 Park Row, New York, is architect and building contractor.

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The Danville Iron & Steel Company, Danville, Pa., has preliminary plans under advisement for the early rebuilding of the portion of its works, recently destroyed by fire, with loss reported at close to \$100,000, including equipment. Two buildings were damaged. The construction is expected to cost close to a like amount.

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The Midwest Steel & Supply Company, East Bradford, Pa., manufacturer of steel stringers and kindred products, has plans for the immediate construction of a new addition to its plant, reported to cost about \$50,000, including equipment. A contract for building only has been let to Simonson & Lundgren, East Bradford. John Hillstrom is general manager.

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The Thomas & Skinner Steel Products Company, Indianapolis, Ind., has acquired a former brass works at Twenty-third Street and the Monon Railroad, and will remodel and improve for a new plant for the manufacture of steel products. The property is 300 x 325 feet, improved with building 150 x 185 feet, providing about 35,000 square feet of operating space. Following alterations, the purchasing company plans to remove its present works to this location, and will arrange for considerable increase in production. New equipment will be installed. J. R. Thomas is president; and O. H. Skinner, secretary and treasurer.

The Southern Malleable Iron Company, Natural Bridge Avenue, St. Louis, Mo., has completed plans and will proceed with the construction of a new addition to its plant at Twenty-first Street and Bona Avenue, East St. Louis, Ill. It will be one-story, 250 x 450 feet, reported to cost close to \$100,000, with equipment. The new structure will replace a plant destroyed by fire a number of weeks ago. B. B. Culver is president.

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The Butler Street Foundry & Iron Company, 3424 Normal Avenue, Chicago, Ill., has plans nearing completion for the construction of a new one-story plant on Normal Avenue, to be 60 x 275 feet, reported to cost in excess of \$50,000. Building contract will be let immediately. A. Epstein, 2001 West Pershing Road, Chicago, is architect and engineer.

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The Mystic Iron Works, Everett, Mass., a subsidiary of the Massachusetts Gas Companies, has blown in its new blast furnace, and plans for continuous operation for some time to come with increased facilities to be developed in connection with the new unit. The company has a tract of more than 300-acres of land. The furnace is 88 feet high, with diameter of 22 feet 6 inches, and hearth diameter of 17 feet; it has a rated output of from 400 to 500 tons of pig iron per day, and will be run on this basis. The plant consists of three stoves, each 22 feet in diameter, and 100 feet high; the blowing apparatus comprises two turbo-blowers, each of 5,000 hp. capacity. In connection with the stack, the company has constructed a power plant with installation of two turbo-generators, each of 750-kw. capacity, and two 500-kw. motor-generators; the boiler plant consists of six 800-hp. water-tube boilers with auxiliary equipment. The operating plant includes three unloaders for ore and limestone handling, with a concrete bin capacity of 10,000 tons; the ore bridge is 450 feet long overall, and has a clear span of 250 feet. Thomas W. Kennedy is vice-president, general manager.

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The Evansville Steel Scaffold Company, Evansville, Ind., has plans for the construction of a new addition to its plant, comprising a one-story saw-tooth roof type structure, 30 x 100 feet, to cost close to \$40,000, with equipment. Work will soon begin. Walter Goodwin is president.

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The St. Bernard Manufacturing Company, St. Bernard, Ohio, affiliated with the Standard Car Wheel Company, 6504 Bessemer Avenue, Cleveland, Ohio, has plans for the construction of a new local plant for the manufacture of iron and steel products. It will be one-story, 105 x 235 feet, estimated to cost close to \$100,000, including equipment.

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The F. P. Lyons Iron Works, Inc., Tampa, Fla., is arranging for the immediate construction of a new local plant, to be equipped as a steel fabricating works. The plant will consist of a main two-story unit, and adjoining one-story structures, and is reported to cost close to \$100,000, including equipment. The machinery installation will provide for an initial handling of about 500 tons of shapes per month, including beams, channels, angle bars, etc. Local offices of the company are at 404 Franklin Street.

The A. P. Green Fire Brick Company, Mexico, Mo., manufacturer of fire brick, furnace refractories, etc., has plans under way for the construction of a new plant unit, to cost more than \$250,000, with equipment. The structure will be one story, 60 x 500 feet. J. H. Brown is secretary.

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The Pratt & Letchworth Company, 189 Tonawanda Street, Buffalo, N. Y., manufacturer of malleable iron products, has completed plans for the immediate construction of a new addition to its plant, to be one story, estimated to cost close to \$30,000, with equipment.

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The American Steel & Wire Company, Worcester, Mass., has work under way on two new additions to its plant, comprising a two-story structure, 65 x 208 feet, and one-story building, 65 x 835 feet, reported to cost in excess of \$225,000. Clinton S. Marshall is district manager.

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The Lukens Steel Company, Coatesville, Pa., has authorized plans for the construction of a new plate mill for its 24-inch sheared plate unit, with roughing mill and finishing mill, and modern auxiliary equipment. The entire project is reported to cost in excess of \$300,000.

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The Otis Steel Company, Riverview Avenue, Cleveland, Ohio, is perfecting plans for the early erection of a new 100-ton open-hearth furnace, and will carry out the project with company forces. It is expected to have the new unit ready for service early in the coming year. The company is now operating four 100-ton open-hearth units, with available space in the open-hearth building for four additional such units.

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The Cleveland Steel Company, Cleveland, Ohio, is arranging for the shutdown of its No. 2 blast furnace and will make extensive repairs in the stack, including relining, etc. With a group of six furnaces, and the No. 6 unit recently blown in, the company will maintain active operations with the entire five available stacks.

TRADE PUBLICATIONS

Heat Resistant Alloys—Southern Manganese Steel Company, St. Louis, Mo., have just issued a new catalog and data sheets pertaining to Fahrloy, a heat and corrosion resistant alloy. Fahrloy is suitable for temperatures up to approximately 2,000 deg. F. It is also used in a number of applications wherein ordinary metals are attacked by acid discoloration and corrosion.

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Steel Rolling Doors and Shutters—Cornell Iron Works, Inc., 71 Marion Street, Long Island City, New York, has just issued a catalog on steel rolling shutters and doors. This catalog describes steel rolling doors and labelled Underwriters' rolling fire doors, and included details of construction, with full dimensions and specifications. It includes fifty actual installations of steel rolling doors and rolling fire doors, in clubs, restaurants, stores, factories, warehouses, etc.

Brass Products—Ohio Brass Company, Mansfield, Ohio, is distributing their new No. 20 O-B general catalog. This book of 945 pages, exceeding the previous edition by 175 pages, includes complete listing of all O-B porcelain insulators, trolley and line materials, rail bonds, car equipment and mining materials. It is logically divided and thumb-indexed for the well-defined classes of products of this company. In addition to descriptive and listing information, there are many helpful suggestions for the man concerned with the installation of these products. Arrangements of the products in the Trolley Materials section of the book is even more convenient than heretofore. Included in this grouping are numerous new products developed and offered to mines since the last edition of the catalog. The books are carefully indexed and convenient, cross-references are plentiful.

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Roller Bearings—Bulletin No. 1560 recently issued by the Hyatt Roller Bearing Company, Newark, N. J., contain data of value to engineers and draftsmen concerned with the designing or development of plant and production equipment. This bulletin is supplemental to other Hyatt publications in that it covers in one volume bearing applications to general types of industrial equipment. Aside from the conventional load and rating tables it includes formulas for determining bearing sizes for specific applications, suggestions for mountings—with drawings—photos of diversified Hyattized equipment, and construction details of all types of Hyatt Roller Bearings.

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Hoists—American Engineering Company, Philadelphia, is distributing a new catalog describing their Lo-Hed electric hoists. This catalog lists for the first time, six large, new hoists that have just been added to the line. These hoists extend the range of capacities up to 24,000 pounds and add an entirely new class of hoists to those which we already were building. This makes four distinct classes, each class being built in from two to six sizes and with various types of suspension and control, including bolt suspension, plain trolley, hand geared trolley, motor trolley and two types of cab hoists and the choice of pendant cord control, push button control and remote control. When desired we can supply an extremely sensitive foundry control for the accurate handling of loads. All hoists are built for both a.c. and d.c.

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Stainless Iron—Bethlehem Steel Company, Bethlehem, Pa., has issued a booklet giving the properties, composition and application of stainless iron and steel manufactured by it. Instructions for working and engineering data are given.

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Centrifugal Compressors—Single stage centrifugal air compressors or blowers as produced by the General Electric Company, Schenectady, N. Y., are described in detail in a bulletin just issued by that company, with ratings and other engineering data.

* * *

Alloy Steel—The Kinite Corporation, Milwaukee, has issued a bulletin describing its cast steel alloy for which is claimed a great resistance to wear, dense close grain and long wear in dies and tools. It is illustrated by halftones of various forms in which it is used, with some account of performance under heavy use.

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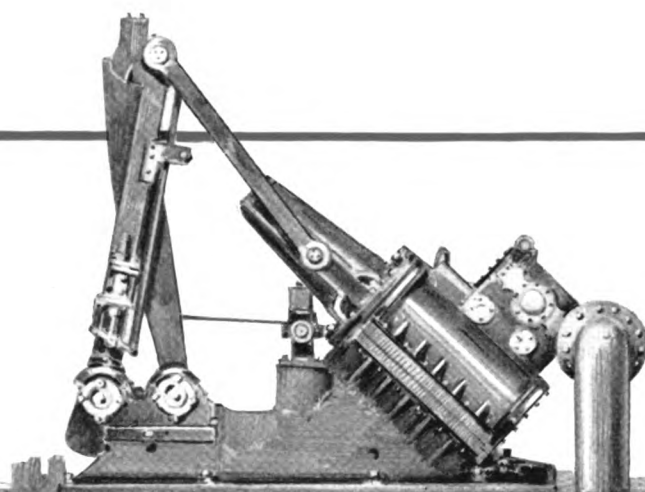
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